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GROUND-WATER RESOURCES OF THE COASTAL PLAIN AREA OF SOUTHEASTERN PENNSYLVANIA

WITH SPECIAL REFERENCE TO THE EFFECTS OF HUMAN ACTIVITIES ON THE QUALITY OF WATER IN THE COASTAL PLAIN SEDIMENTS

By

DAVID W. GREENMAN, DONALD R. RIMA,
WILLIAM N. LOCKWOOD, AND HAROLD MEISLER

DEPARTMENT OF INTERNAL AFFAIRS

Genevieve Blatt, Secretary

TOPOGRAPHIC AND GEOLOGIC SURVEY

Carlyle Gray, State Geologist

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FOREWORD

Ground water studies in Pennsylvania are carried out under a cooperative program with the United States Geological Survey, Ground Water Branch. The program is planned jointly by the Chief Geologist, Bureau of Topographic and Geologic Survey, and the District Geologist, United States Geological Survey.

This report is the first to be published in a new series of studies directed to the detailed and quantitative analysis of geologically related water-bearing rocks, or aquifers. It is felt that by directing a study toward a specific aquifer or group of related aquifers, a more effective attack could be made on the problems of determining quantitatively the water-yielding potentials of the rocks than is possible by attempting to analyze the heterogeneous rocks of a political or geographic subdivision.

We feel that this report well justifies the new approach and promises much success for the continuing program.

Genevieve Blatt

GENEVIEVE BLATT
Secretary of Internal Affairs

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GROUND-WATER RESOURCES
OF THE
COASTAL PLAIN AREA OF SOUTHEASTERN PENNSYLVANIA

with special reference to

The Effects of Human Activities on the Occurrence of Ground Water in the Coastal Plain Sediments

by David W. Greenman, Donald R. Rima, William N. Lockwood, and Harold Meisler

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ABSTRACT

The Coastal Plain of southeastern Pennsylvania occupies a long narrow area adjoining the Delaware River between Morrisville, Pa., and the Delaware State line. It is bounded on the south and east by the Delaware River and on the north and west by the Fall Line, which defines the inner or landward margin of the Coastal Plain.

The area includes two subareas of contrasting economic development. Southern Philadelphia is one of the oldest and most intensely developed industrial and commercial centers in the United States. Southeastern Bucks County, on the other hand, a rural and suburban area, has experienced phenomenal economic development since the end of World War II and now ranks among the most rapidly growing urban communities in the United States. Ground water has been and will be an important asset to the economy of southern Philadelphia, but its utility has depreciated in recent years owing to contamination of the aquifers. Similarly, ground water is and will be an important resource in the future development of southeastern Bucks County, but maximum utilization will never be achieved if contamination of the aquifer is tolerated as a concomitant of urban activity.

The Coastal Plain was naturally endowed with abundant supplies of ground water of excellent quality. The combination of a humid, temperature climate, and a flat lowland topography assured the availability of recharge. Most important, the geology of the area favors storage and circulation of ground water. The area is underlain principally by two kinds of rocks — unconsolidated sediments of the Coastal Plain, which range in age from Cretaceous to Recent, and older crystalline metamorphic rocks which form the basement complex beneath the Coastal Plain sediments. The Coastal Plain sediments include the principal aquifers of the area.

The crystalline rocks crop out northwest of the Fall Line, and slope southeastward below the Coastal Plain sediments. The most important hydrologic features of the bedrock floor are the incised channels of the ancestral streams that traversed the area. These channels contain accumulations of Cretaceous rocks which are the most reliable and productive aquifers among the Coastal Plain sediments. The ancestral Schuylkill River is represented by four southeast-trending channels carved into the bedrock floor beneath south Philadelphia, and the ancestral Delaware River and its tributaries are represented by at least five lesser troughs beneath southeastern Bucks County.

The oldest Coastal Plain sediments deposited in the troughs belong to the Raritan formation of Late Cretaceous age. The Raritan formation has been subdivided into six members in this area. In ascending order these are the Farrington sand, the lower clay, the Sayreville sand, the middle clay, the Old Bridge sand, and the upper clay. The Raritan formation is overlain in adjacent parts of New Jersey by the Magothy formation but in the area of this report almost entirely by Pleistocene deposits consisting chiefly of coarse sand and gravel interbedded with clay, silt, and fine sand. These, in turn, are overlain by Recent flood-plain deposits.

Ground water occurs under both artesian and water-table conditions in the Coastal Plain sediments. The artesian system, which includes the Farrington and Sayreville members and their overlying confining beds, is part of the artesian system that underlies much of southern New Jersey. Natural recharge to the system occurs in a high-level intake area east of Trenton, N. J., from where the water moves eastward to low-lying discharge areas along the Atlantic Ocean and southwestward to the valley of the Delaware River.

The Farrington sand is the principal aquifer in southern Philadelphia where it attains local thicknesses ranging from 70 to 90 feet. Typical wells in those areas yield from 700 to 1,100 gpm (gallons per minute) and have specific capacities ranging from 20 to 30 gpm per foot of drawdown. The Sayreville member is an important source of ground-water supplies in southeastern Bucks County where it attains a maximum thickness of about 50 feet in the deeper parts of the bedrock troughs. Wells in those areas yield from 300 to 700 gpm and have specific capacities ranging from 15 to 25 gpm per foot of drawdown.

The regional water-table unit comprises the Old Bridge sand member of the Raritan formation, and the overlying permiable beds of Pleistocene and Recent ages. The occurrence of ground water in the water-table aquifers in Philadelphia and Bucks Counties is controlled by the local environment. Recharge is obtained from local precipitation, and ground-water drainage is directed toward local surface-drainage courses.

The Water-table aquifers are important sources of supply throughout the Coastal Plain, and they are the principal sources of ground water in southeastern Bucks County. The water-bearing properties of these beds differ greatly from place to place according to the thickness and character of the sediments. Modern wells penetrating 10 to 15 feet or more of saturated sand and gravel commonly

yield 400 gpm or more and have specific capacities on the order of 20 gpm per foot of drawdown. The most reliable and productive wells are near surface sources of virtually unlimited recharge, such as the Delaware River or the artificial lakes in southeastern Bucks County.

Human activities have changed significantly the natural hydrologic environment in the Coastal Plain of southeastern Pennsylvania, and most of the changes have been detrimental to the ground-water resources.

The quality of ground water and, thus, its economic utility, has depreciated severely because of the effects of urban development in south Philadelphia. The water-table aquifer showed the earliest effects of contamination. Most of the recharge area for the aquifer had been either covered with buildings and pavements or polluted with municipal and industrial dump. Furthermore, contaminated recharge was introduced directly in the aquifer by leakage from sewers and cesspools. Pollution of recharge areas has been aggravated by the continued concentration of industrial activity in southern Philadelphia.

The character of the contaminated waters—that is, the relative concentration of the various ions in solution—differs according to local recharge conditions. Industrial wastes commonly are rich in sulfate or chloride, organic wastes in nitrate, and leachings from landfill in bicarbonate. The contaminated waters commonly contain relatively large concentrations of iron and carbon dioxide and are corrosive.

As a result of the contamination, utilization of the water-table aquifer in southern Philadelphia has proceeded spasmodically. The average daily pumpage was about 5 mgd (million gallons per day) in 1920 and only 10 mgd in 1940, although several hundred wells had been installed. Since 1940 pumpage from the water-table aquifer has remained relatively constant, but in 1958 practically all withdrawals were concentrated in the area marginal to the Delaware River, upstream from the Philadelphia Naval Base, where the effects of pollution are somewhat mitigrated by induced infiltration of water of relatively good quality from the river. According to recent analyses of water from every available water-table well in southern Philadelphia, the quality of the water has depreciated to the extent that not one of the supplies tested meets the recommended threshold standards for drinking water supplies or industrial cooling use — the two major uses of ground water in the area.

The artesian aquifers in southern Philadelphia have a similar but not so advanced history of contamination. Pumpage from the Farrington sand member began in the early years of the 20th century and showed a steady increase to about 5 mgd in 1920 and 15 mgd by 1940, largely from wells in the Greenwich Point trough. Sustained pumpage caused a reduction in artesian head which in turn promoted local recharge of highly polluted water from the overlying water-table aquifer. The first effects of contamination were noted in wells near the inland margin of the aquifer, but by 1940 the zone of contamination extended to all centers of pumping in the Greenwich Point trough. Between 1940 and 1945 withdrawals from the Farrington member increased to about 23 mgd largely due to installation of a well supply for the U. S. Naval Base at League Island. As this was a virgin area of development the quality of water remained excellent for several years, but deter-

ioration began before the end of World War II, and by 1950 all of the principal supply wells at the Naval Base showed severe effects of contamination. Pumpage declined to about 18 mgd by 1951, largely as a result of the continued depreciation of the quality of water, and it has fluctuated around that figure since then. The bulk of present supplies are obtained from wells tapping the Farrington sand member in the parts of the troughs that are remote from sources of local recharge.

None of the current supplies of artesian water meets recommended standards for drinking water or industrial cooling use, although some is being used for air conditioning and industrial cooling. Maximum utilization of the resource in southern Philadelphia hinges on the development of economic methods for use or treatment of the contaminated water.

Human activities have had much different and less detrimental effects on the occurrence of ground water in southeastern Bucks County. Although the area is now experiencing intense urban development, the principal changes in the natural environment stem from land-use practices related to the rural and suburban history of the area. For example, the natural regimen was disturbed by sand- and gravel-dredging operations which removed the water-table aquifer from beneath about 8 per cent of the Coastal Plain terrain in southeastern Bucks County. This activity has had some desirable consequences, as the artificial lakes created by the dredging operations are important sources of recharge to the contiguous water-table aquifer.

Agricultural practices have influenced the quality of ground water in truck farming areas of southeastern Bucks County. For example, repeated applications of fertilizers to farm plots has caused an increase in the concentration of nitrate in the ground water. Also, the increased biologic activity in the artificially enriched soils has accelerated decomposition of minerals, thereby providing more material for solution by recharge waters. As a result, water from the water-table aquifer in agricultural areas commonly is moderately mineralized and has a relatively high concentration of nitrate. However, this form of contamination is more a subject of academic interest than a problem of ground-water development, because few, if any, supplies have been seriously contaminated by agricultural practices.

Contamination from industrial wastes has not been an important problem in southeastern Bucks County. Only two wells are known to be seriously affected; these are remote from one another and the contamination is derived from local sources of recharge. Thus, human activities have caused some depreciation of the quality of ground water in southeastern Bucks County, but most supplies are of satisfactory quality for practically any use with only minimal treatment. Ground-water development in southeastern Bucks County has followed a more orderly pattern than was possible in Philadelphia County. The first large-capacity industrial wells were installed about 1911, and in the following 30 years there was a modest but steady increase in pumpage to meet new industrial needs. After World War II, development of industrial and public supplies accelerated to match the economic growth of the area, and by 1956 the average daily pumpage totaled about 13 mgd and showed no signs of leveling off. The major supplies are concentrated in four areas of urban activity, and the future growth of these communities will undoubtedly result in an increased demand for ground water.

Development of additional ground-water supplies in southeastern Bucks County is entirely feasible, because current withdrawals are only a small fraction of the potential yield of the aquifers. However, future changes in water quality could limit development, as urbanization of southeastern Bucks County probably would be as harmful to the quality of the ground water as it was in southern Philadelphia. Furthermore, the artificial lakes in southeastern Bucks County offer special opportunities for underground contamination. As the pressure on land resources increases efforts may be made to reclaim these lakes by means of sanitary landfill projects. Such practices will have drastic effects on the quality and availability of ground water and, in combination with other anticipated byproducts of urbanization, will probably create even more severe contamination problems than have been experienced in southern Philadelphia. Future utilization of ground water in southeastern Bucks County will depend largely upon the success of whatever measures are taken to protect the ground water from the consequences of urban development.

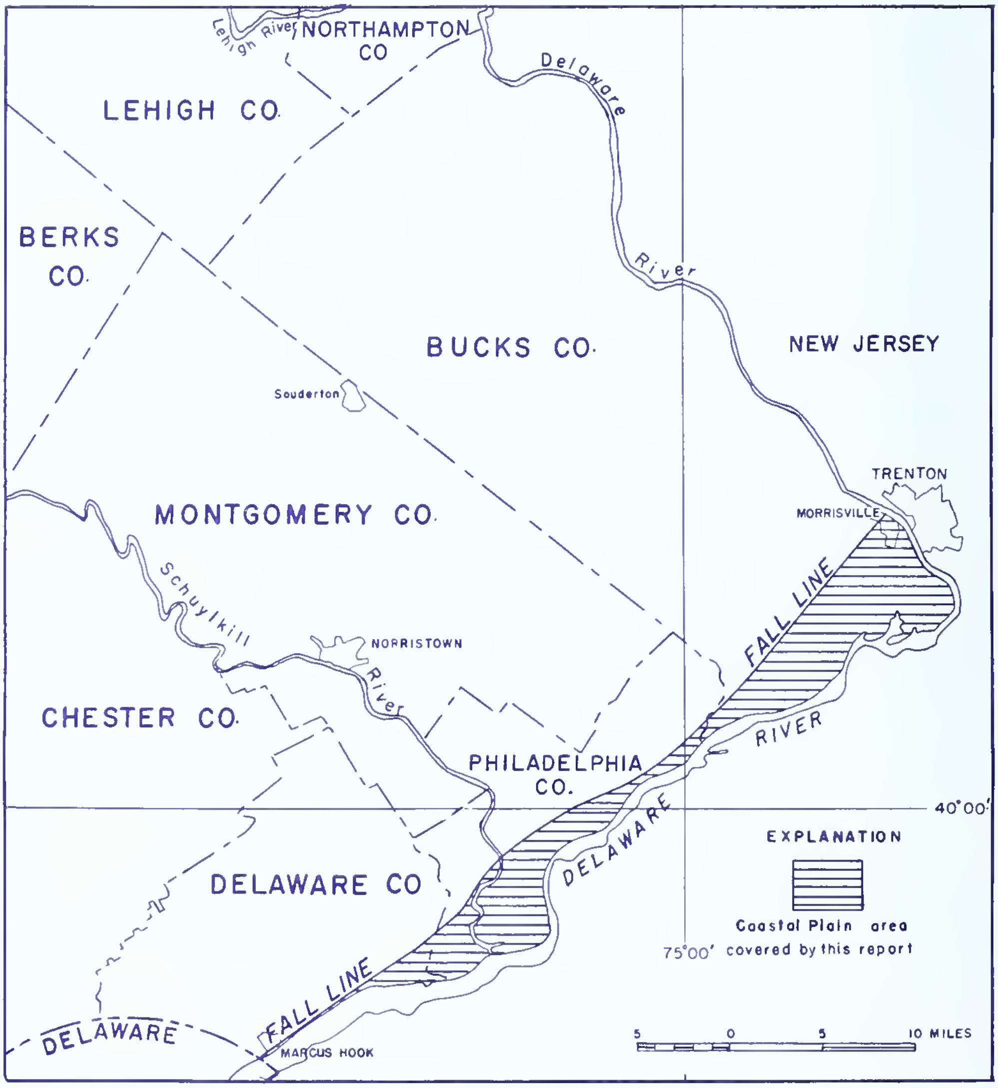


Figure 1.
Map of southeastern Pennsylvania showing the area covered by this report.

INTRODUCTION

Location of the Area

The area discussed in this report is the small part of the Coastal Plain physiographic province that occurs in the southeastern part of the Commonwealth of Pennsylvania, adjacent to the lower Delaware River between Morrisville, Pa., and the Delaware State line (Fig. 1). It is bounded on the south and east by the Delaware River, which constitutes the border between Pennsylvania and New Jersey, and on the north and west by the Fall Line, which defines the inner or landward margin of the Coastal Plain.

This area is in the heart of the thickly populated, highly industrialized lower Delaware River valley. It includes a substantial part of the City of Philadelphia and most of the newly industrialized section of Bucks County. About 1 million people reside within the report area. and an additional 2 million people reside in contiguous areas of Pennsylvania and New Jersey. The population density is greatest in the City of Philadelphia where it exceeds 16,000 people per square mile. Since 1950 the southeastern part of Bucks County has had a tremendous population growth, which is explained in part by the construction of the Fairless Works by the U. S. Steel Corp. at Morrisville, Pa., and the subsequent development of two large residential areas — Levittown and Fairless Hills.

According to figures released by the Bureau of Statistics, Pennsylvania Department of Internal Affairs, industries in the area produced goods valued at approximately $5 billion in 1954. The major classes of products include metals, foodstuffs, chemicals, and textiles. The Port of Philadelphia, which handled nearly 80 million short tons of water-borne commerce in 1954, is second in the United States to the Port of New York. The area covered by this report is served by three major railroads, six major airlines, and an elaborate network of interstate highways.

Purpose and Scope of the Investigation

The abundant ground-water resources of the lower Delaware River Valley have been an important factor in the industrial growth of the region. The development of ground-water supplies. however, has proceeded haphazardly and without an adequate knowledge of the

geology and hydrology of the area. Consequently, the usefulness of the supply is seriously threatened by widespread contamination. For example, the withdrawal of ground water from certain parts of south Philadelphia has induced the recharge of water of inferior quality. Water obtained from wells in those areas could only be used by resorting to treatment to remove undesirable mineral contaminants. This situation has created a growing concern over the possibility that ground-water supplies in other parts of the region might be similarly affected.

The realization that ground water is a critical factor in the economy of the area prompted the investigation described in this report. The purpose of the investigation was to study in detail the hydrology of the unconsolidated sediments underlying the Coastal Plain area in southeastern Pennsylvania. The geology of the area was studied to determine the areal and vertical distribution of the geologic formations penetrated by wells and to obtain information on the texture, thickness, and continuity of the water-bearing zones. Hydrologic studies were made to determine the occurrence and availability of ground water, to identify sources of recharge and points of discharge, and to determine the rate and direction of ground-water movement in the major aquifers. Considerable emphasis was placed on the quality of ground water and to the causes for the marked deterioration in the quality of water obtained from wells in certain areas.

Methods of Investigation

Information on subsurface geology was obtained from the collection and interpretation of drillers' logs of wells and borings and by miscroscopic examination of drill cuttings from numerous wells. Maps and cross sections were constructed from the information thus obtained. To supplement the available subsurface geologic information, about 20 shallow test wells were drilled in southeast Bucks County by means of a power auger owned by the U. S. Geological Survey.

Most of the data on the occurrence of ground water was obtained by a detailed inventory of all ground-water supplies in the area. Data on wells were obtained by examining the available records of industrial establishments, municipalities, and well-drilling companies and by interviewing well owners or their representatives. The information recorded for each well included the details of well construction,

the original static water level, the yield in comparison to drawdown, and the average pumping rate. The locations of the wells inventoried are shown on Plates 1 and 2.

A network of observation wells was established to evaluate the effects of past and present withdrawals upon the hydrologic regimen. Water levels were measured periodically in several wells and selected wells were equipped with continuous water-stage recorders. Hydrographs were plotted to determine water-level trends and piezometric maps were made for areas where the principal aquifer was pumped heavily.

Pumping tests were made at seven locations to determine the capacity of the water-bearing materials to store and transmit water. The results, expressed as coefficients of storage, transmissibility, and permeability, were used to estimate the effects of withdrawals from wells on the hydrologic regimen.

Water samples for chemical analyses were collected from representative wells as they were inventoried to obtain information on the geologic and geographic pattern of water quality. Additional samples were collected and analyzed periodically to evaluate the nature and degree of change of the quality of ground water both areally and with depth. With this information it has been possible to interpret the effect of various sources of recharge on the quality of ground water.

Well-numbering System

The well-numbering system used in Pennsylvania includes a well-identification number and a well-location number. The identification number consists of a two-letter symbol for the name of the county in which the well is located followed by a serial number beginning with 1 in each county. The county symbols used in this report include Bk for Bucks County and Ph for Philadelphia County. Thus, Ph-100 identifies the 100th well scheduled in Philadelphia County.

The well-location number is composed of two parts separated by a hyphen such as J24c-1627. The first part, J24c, refers to the coordinate system used in Pennsylvania to identify individual 7½ minute quadrangle maps. The coordinate system employs the use of the

letters A through L (except I) along the west border of the State to designate from north to south each 15-minute interval of latitude. Similarly the numbers 1 through 25 are used along the north border to designate from west to east each 15-minute interval of longitude. Thus, the capital letter and the number that follows it designate a 15-minute quadrangle which is further subdivided into four 7½ minute quadrangles by using lower case letters "a", "b", "c", and "d" to represent the northwest, northeast, southwest, and southeast quarters respectively.

The second part of the well-location number consists of a four-digit number that identifies the northwest corner of a one-hundredth square mile area (6.4 acres) within any 7½ minute quadrangle map. The first two digits refer to the number of tenths of a mile between the northern boundary of the 7½ minute quadrangle map and the northern boundary of the one-hundredth square mile area containing the well site. Similarly the last two digits refer to the distance between the western boundary of the 7½ minute quadrangle map and the western boundary of the one-hundredth square mile area containing the well site. Thus a well with the location number J24c-1627 is situated between 1.6 and 1.7 miles south and between 2.7 and 2.8 miles east of the north and west boundaries, respectively, of the 7½ minute quadrangle map designated "J24c".

Borings used in the compilation of this report have been numbered serially throughout the report area. Each serial number is prefixed by an upper case B to distinguish it from serial numbers of wells. The locations of all borings used are shown on the well-location maps, Plates 1 and 2.

Personnel and Supervision

The investigation was made by the U. S. Geological Survey in cooperation with the Pennsylvania Topographic and Geologic Survey, Department of Internal Affairs. The work was performed under the general supervision of A. N. Sayre, Chief of the Ground Water Branch and his successor, P. E. LaMoreaux; H. C. Barksdale, Atlantic Coast Branch Area Chief; the late S. H. Cathcart, State Geologist of Pennsylvania and his successor, Carlyle Gray. Direct supervision was given by J. B. Graham, District Geologist, and his successors, P. H. Jones,

D. W. Greenman, and J. E. Barclay. Most of the basic information on the geology and hydrology of the area was collected by N. H. Klein, J. C. Kammerer, and W. A. Mourant. N. H. Blanchard assisted in the preparation of illustrations and in the tabulation of data. Seymour Mack contributed to the early synthesis and interpretation of the data on geochemistry. Water samples collected from wells during the course of this investigation were analyzed by the U. S. Geological Survey laboratory, Philadelphia, Pa.

Previous Ground-water Investigations

The earliest references to the occurrence of ground water in the Coastal Plain sediments of southeastern Pennsylvania are in the annual reports of the State Geologist of New Jersey. Beginning in 1893, these reports contained brief descriptions of newly drilled "artesian" wells in Philadelphia, Pa. In 1904 most of this information was included in a report describing the water resources of the Philadelphia district (Bascom, 1904).

In 1925 the U.S. Geological Survey, in cooperation with the Pennsylvania Topographic and Geologic Survey, began a series of reconnaissance-type investigations of the ground-water resources of the entire State. In 1934 a report covering southeastern Pennsylvania was published by the State cooperating agency (Hall, 1934). It contains a description of the geology and water-bearing properties of the Coastal Plain sediments and a brief summary of the ground-water resources of Bucks and Philadelphia Counties.

In 1943 the cooperative ground-water program in Pennsylvania was expanded to provide for more comprehensive local studies. Since that time four moderately detailed reports have been published covering parts or all of the area of this report. As a contribution to the development of southeastern Bucks County a report summarizing available information on the water resources of the area was prepared by Graham, Mangan, and White (1951). In 1952 a comprehensive report described the ground-water resources of the U.S. Naval base at Philadelphia (Graham and Kammerer, 1952). In 1955 a report on the geology and ground-water resources of Bucks County was published (Greenman, 1955). In 1952 a comprehensive report covering

the Tri-State region adjacent to the lower Delaware River was published as a result of a joint investigation designed to evaluate and appraise the ground-water resources of the lower Delaware River basin (Barksdale and others, 1958).

Hydrologic investigations were in progress in 1958 in the entire Delaware River basin, to supply the Corps of Engineers, U. S. Army, with essential water facts for planning the systematic development and conservation of the total water resources of the basin. These investigations were being made by the General Hydrology Branch, Water Resources Division, and a final report was in preparation.

Acknowledgments

The writers wish to acknowledge the excellent cooperation and valuable assistance received from the industrial firms and other well owners in the area, consulting engineers, water-well contractors, and governmental agencies—local, state, and federal. Special thanks are due the Publicker Commercial Alcohol Co. of Philadelphia for permission to use their wells for pumping tests; the U. S. Steel Corp. and the Warner Co., both of Morrisville, for supplying the logs of borings made on their properties and contributing sites for the drilling of additional test holes for the collection of geologic data; and the Pennsylvania Railroad Co., Gulf Oil Corp., and the Atlantic Refining Co. for their helpfulness in providing wells for observation purposes. Appreciation is also expressed to the officials of the Bristol Borough Water Department, the Lower Bucks County Joint Water and Sewer Authority, the Falls Township Water Authority, and the Morrisville Water Department, who gave freely of their time in supplying information on their ground-water developments.

Many governmental agencies were most helpful during the course of the field work and subsequent preparation of the report. The Bureau of Statistics, Pennsylvania Department of Internal Affairs, furnished data on the use of ground water in the area; the U. S. Naval Base, at Philadelphia, had test wells constructed for the collection of geologic and hydrologic data; and several departments of the City of Philadelphia contributed valuable information obtained from test borings made throughout the city.

General Features of the Area

Surface Features

The area covered by this investigation lies within the Coastal Plain physiographic province as described by Fenneman (1938, p. 1). The inner or landward margin of the Coastal Plain is called the Fall Line, which is identified topographically by an abrupt transition from the rolling hills of the Piedmont to the flat lowlands of the Coastal Plain.

The topographic differences between these two regions reflect the differences in the composition and structure of the rock materials underlying their surfaces. The Piedmont is underlain by dense, hard, crystalline rocks that offer considerable resistance to erosion and support an uneven hilly surface, which stands well above the general level of the adjacent Coastal Plain. The Coastal Plain is underlain by soft unconsolidated deposits that yield readily to the processes of erosion and form low nearly flat plains and broad shallow valleys.

Within the area of this investigation the land surface has a gentle slope from the Fall Line southeast to the Delaware River. The general level of the land surface rises from sea level along the river to about 40 feet above mean sea level at the Fall Line. The uniformity of the surface is interrupted locally by features of the present cycle of erosion.

Drainage

The area of this investigation is drained by the Delaware River and its tributaries. The Delaware River enters the Coastal Plain at Trenton, N.J., where it becomes a tidal stream, and flows in a general southwesterly direction across the area. Its average discharge at Trenton, as reported in Water-Supply Paper 1272 (U. S. Geol. Survey, 1956, p. 220), is slightly more than 12,000 cfs (cubic feet per second). The flow of the river is affected by tides, which increase in amplitude in an upstream direction as far as the Fall line. A tongue of salty or brackish water moves upstream as far as Marcus Hook, Pa. near the extreme southwestern end of the area (Fig. 1). At times of protracted low flow, however, an increase in the salinity of the river water as far upstream as Trenton, N. J., was noted by Durfor and Keighton (1954, Fig. 7).

The major tributaries to the Delaware River, including the Schuylkill River, Frankford Creek, Pennypack Creek, Poquessing Creek, and Neshaminy Creek, flow southeasterly across the Piedmont. Upon entering the Coastal Plain their gradients are reduced considerably and they meander across the Plain. The largest of these, the Schuylkill River, enters the Delaware River at Philadelphia and has an average discharge of about 2,900 cfs. The next largest is Neshaminy Creek which discharges approximately 300 cfs into the Delaware River at a point 2 miles downstream from Bristol, Pa. No data are available on the discharge of the smaller tributaries, but it is doubtful that the sum of the average discharges of these streams exceeds 400 cfs.

A large part of the area is drained by small unnamed streams that have their origins within the Coastal Plain. These streams have a dendritic drainage pattern and generally enter the major streams and rivers at right angles.

Climate

The Coastal Plain area of southeastern Pennsylvania has the mildest climate of any area in the Commonwealth. In an average winter the temperature rarely goes below 0° F., and in the summer temperatures rarely rise above 100° F. Snow cover generally occurs for a total of less than 30 days in a typical year. Owing to its proximity to the ocean the area has a relatively high humidity, averaging about 57 percent annually.

The climate of the Coastal Plain is highly favorable for the replenishment of ground water. Precipitation is abundant and is uniformly distributed throughout the year. Hence, water from the atmosphere is available for recharge in late fall, winter, and early spring when losses to evaporation and plant transpiration are at a minimum. Moreover, mild winter temperatures prevent the accumulation of ground frost which might form a barrier to recharge.

Precipitation and temperature data are given in table 1.

Table 1.—*Precipitation and temperature at International Airport, Philadelphia, Pa.,* (1942-1958)

(Source: U. S. Weather Bureau)

Month	Precipitation (inches) Maximum	Minimum	Normal	Average monthly air temperature (°F.)
January	6.06	0.45	3.37	33.2
February	4.64	1.37	3.02	33.6
March	6.27	1.72	3.32	42.3
April	6.58	1.14	3.38	51.6
May	7.41	0.91	3.58	63.1
June	6.69	0.11	3.87	72.1
July	7.16	0.64	4.20	76.3
August	9.70	0.65	4.58	74.0
September	5.82	0.88	3.46	67.7
October	5.21	0.49	2.60	56.6
November	5.83	1.08	3.08	45.9
December	5.48	0.25	2.67	35.9
Annual			41.13	

PRINCIPLES OF GROUND-WATER HYDROLOGY

Occurrence and Movement

Ground water is defined as that part of the water beneath the surface of the earth that occurs in the zone of saturation. In the zone of saturation all the connected pores, crevices, and voids in the rock are filled with water under hydrostatic pressure. The number, size and shape of the rock openings, and the degree of interconnection between them, determine the effectiveness of any saturated rock unit as a source of water. A body of rock that yields sufficient water to make it an economic source of supply is called an aquifer.

Nearly all the rocks that form the crust of the earth have openings which contain and transmit water. These rock openings are classified as primary and secondary. The primary openings are the interstitial voids formed during the deposition of the sediments. The secondary

openings are cavities that develop as a result of crustal movements, solution, or the action of destructive weathering processes that modify rock after it is deposited. Unconsolidated sediments contain primary openings only. Consolidated rocks may contain some primary openings but most of the openings in such rocks are secondary along bedding planes, planes of schistosity, joints, and other fractures, some of which have been enlarged by solution.

As a part of the earth's natural drainage system, ground water moves under the influence of gravity from intake areas toward lower levels and ultimately to points of discharge. The direction and rate of movement are controlled by the "hydraulic gradient," which is defined as the difference in head between two points divided by the line-of-flow distance between them. Unlike flow on the land surface, where water moves freely in open channels, ground-water flow is through openings in the rock. Because most of these openings are small, they offer considerable resistance to the flow of water. Consequently, the natural rate of ground-water movement is slight compared to that of surface water, and is commonly measured in terms of feet or fractions of a foot per day, or even per year.

Precipitation is the source of all ground water. Ground water may be derived either from local precipitation or, more commonly in arid regions than in Pennsylvania, from streams whose channels are cut into water-bearing beds. Under natural conditions the Coastal Plain sediments were replenished entirely by precipitation that fell within the outcrop area of the individual formations, but since wells of large yields first tapped these sediments a part of the recharge has been furnished by induced infiltration of water from the Delaware River and its tributaries.

Two of the most useful hydraulic characteristics of an aquifer are expressed as its coefficients of storage and transmissibility. The coefficient of storage is defined as the volume of water released or taken into storage by the aquifer per unit surface area of the aquifer per unit change in the component of head normal to that surface. The coefficient of transmissibility is defined as the amount of water, in gallons per day at the prevailing temperature of the water, that will flow through a vertical section of the aquifer 1 foot wide and extending the full saturated height, under a unit hydraulic gradient.

The coefficient of transmissibility is an expression of the principal factor determining the amount of drawdown in a pumped well because the ability of an aquifer to transmit water controls the slope of the cone of depression.

The rate of expansion of the cone of depression — or the rate of transmission of the effect of withdrawal — varies inversely as the coefficient of storage of the aquifer and directly as the coefficient of transmissibility.

A common expression for describing the productivity of an aquifer is its specific capacity. Specific capacity is defined as the yield of a well per unit decline of water level, and is commonly expressed as gallons per minute per foot of drawdown. The specific capacity of a well is closely related to and generally varies directly with the transmissibility of the aquifer.

Ground water may occur under either water-table or artesian conditions. Under water-table conditions the ground water is not confined, the water level in the aquifer is free to fluctuate, and the water level in a well marks the upper surface of the zone of saturation. This surface is called the water table. Under artesian conditions there is no water table, as the ground water is confined under hydrostatic pressure between two relatively impermeable bodies of rock, and the water level in a tightly cased well tapping the artesian aquifer will rise above the upper limit of the aquifer. The imaginary surface defined by the levels to which the water will rise in wells tapping the artesian aquifer is called the piezometric surface of the aquifer.

There are significant differences in the behavior of ground water in water-table and artesian aquifers. Water-table aquifers function as natural reservoirs of ground water from which withdrawals can be made. Water-table conditions occur in the catchment areas of artesian aquifers, where the aquifers are exposed to direct recharge from infiltration of precipitation or surface water. The water table is generally a subdued replica of the surface topography and the direction and slope of the natural hydraulic gradient in any locality is related to the local topography. The ground water drains from the uplands towards the valleys and is discharged through springs or seeps along the valley walls and in stream beds.

The storage coefficients of water-table aquifers generally range from 0.01 to 0.40 and commonly are greater than 0.10. Water withdrawn from a water-table aquifer is supplied from aquifer storage by draining the pore spaces of the saturated rock in the vicinity of the place of withdrawal. The decline in water level around the point of discharge occurs in the form of an inverted cone which expands until it induces recharge or captures natural discharge in amounts sufficient to balance the withdrawal. Because of the large storage capacity of water-table aquifers, the cone of influence expands more slowly and does not usually extend as far from the point of discharge as it does in an artesian aquifer. Consequently, fluctuation of water level in one area will not appreciably influence water levels in other areas, and excessive local withdrawals during droughts may cause critical declines of water level in water-table aquifers although nearby areas are not affected by the pumping.

An artesian aquifer functions largely as a natural conduit. It is recharged chiefly in the area of outcrop where the aquifer is under water-table conditions and then transmits the ground water, under hydrostatic pressure, to points of escape where the confining bed is absent or broken or where water is withdrawn through wells. Artesian aquifers favor long-distance circulation of ground water. As under water-table conditions, the ground water moves in the direction of the hydraulic gradient, but the hydraulic gradient of an artesian aquifer is commonly more persistent over wide areas than that of a water-table aquifer because it is not necessarily influenced by local topographic features.

The storage coefficient of artesian aquifers is commonly less than 0.001 and is related principally to the elasticity of the aquifer and not to the drainable pore space as is the case in a water-table aquifer. Artesian aquifers may have as large a porosity as water-table aquifers, but the yield of an artesian well is not supplied by dewatering the aquifer —rather it is derived from compaction of the aquifer skeleton and, to a minute extent, expansion of the water as the hydrostatic pressure is decreased in response to the withdrawal of water. When an artesian well discharges, the resulting decline of pressure head is transmitted rapidly through the aquifer to outcrop areas or boundaries where the rates of discharge and recharge adjust to balance the withdrawal.

True artesian conditions rarely exist in nature because no rock is completely impervious. A confining bed need only be less permeable than the underlying aquifer to produce an artesian head in that aquifer. A leaky artesian aquifer is one which, under conditions of heavy withdrawals, receives significant recharge by vertical movement of water through the confining bed or beds. Similarly, water-table aquifers may be overlain by local, discontinuous confining beds which impede vertical movement of water and give rise to local artesian conditions. However, these local conditions do not support a widespread regional pattern of movement, such as occurs under artesian conditions, because recharge and discharge are local and are linked by a flow pattern that is largely controlled by the topography.

Quality of Ground Water

The chemical and physical properties of ground water are important characteristics to consider in any description of the hydrology of an aquifer. The chemical character of ground water, for example, is related to its source of recharge and to its geologic habitat; and in many instances it determines the usability of the aquifer as a source of water.

Chemical Character

All natural ground waters contain mineral materials derived from the atmosphere, soil, and rock with which the water has been in contact. These materials include dissolved constituents as anions and cations in chemical equilibrum with one another and as molecules in colloidal suspension which do not enter into the chemical equilibrium of the solution.

Chemical analyses are expressed in terms of parts per million (ppm) and equivalents per million (epm). Parts per million is a simple weight ratio and can be used to report the concentration of any constituent. Equivalents per million is also a weight ratio and it relates to the equivalent weights of constituents in solution so the sums of the cations and anions are equal. It is used to report only the concentrations of constituents that occur as ions in solution.

Carbon dioxide (CO_2) dissolved from the atmosphere and soil zone probably is the first important constituent acquired by water as it proceeds through the hydrologic cycle. Carbon dioxide reacts with water to form carbonic acid:

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

and

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

The corrosive character of the water is further increased by solution of organic acids from the soil zone. The weak acidic solution then reacts with mineral material in the soils to take other constituents into solution. Thus the quality of natural ground water is primarily a function of the composition of the recharge water, the types of rocks with which the water has come in contact, the length of time of contact, and the conditions, such as temperature and pressure, under which the contact took place.

Human activities also cause significant changes in the chemical quality of ground water through a number of means. Mineral and organic impurities may be introduced directly into aquifers through wells used for disposal of sewage and industrial wastes. Widespread and appreciable changes in the chemical quality of ground water in some areas also may result from large withdrawals of water from an aquifer. For example, a given aquifer may be hydraulically continuous with another aquifer or with a surface supply containing water of a different chemical character. Under natural hydraulic gradients the movement of water may be from the first aquifer toward the other reservoirs, but when water is withdrawn from the first aquifer a reversal of the hydraulic gradient may induce recharge to the aquifer from the other reservoirs. Recharge from a new source modifies the quality of water in an aquifer, and, in time, the water tends to resemble that of the new source.

Pumping from water-table aquifers often has an indirect effect on the quality of the water as a result of chemical reactions in the dewatered zone. Lowering of the water table exposes mineral and organic matter to oxidation and carbonation, and some of the products of these processes are taken into solution and transported to the water table by downward percolating water.

The principal cations in solution in ground water are two alkaline earths, calcium and magnesium, and one alkali, sodium. Another alkali, potassium, also occurs, but it is much less abundant. Iron may occur as ferrous ions in solution in the presence of dissolved carbon dioxide. In natural waters the quantity of iron in solution is slight, probably less

than 0.1 ppm in most instances. However, the concentration of iron in solution may be several parts per million or more where the aquifer is exposed to artificial contamination from acid industrial wastes or from organic refuse, such as leachings from dump grounds, which may contain considerable dissolved carbon dioxide. The concentration of iron in ground water is significant, therefore, because small increases in its concentration indicate possible contamination.

The principal anions in solution are bicarbonate, sulfate, and chloride. Nitrate usually occurs but generally only in trace concentrations in natural waters; where its concentration exceeds more than a few parts per million, it can frequently be attributed to organic contamination from some human activity.

Standards of quality are as numerous as uses of water. Properties that make a water unfit for one use may not affect its utility for other purposes. For example, moderate concentrations of silica do not affect potability of water, but they render it unfit for boiler use. On the other hand, public supplies must meet sanitary requirements and be free of objectionable colors and odors, but these factors are not especially important for many industrial purposes — including cooling, the principal industrial use of water. Quality of water standards are described in considerable detail in "Water Quality Criteria" (California Water Pollution Control Board, Pub. No. 3, 1957). For the purposes of this report recommended standards for drinking-water supplies and for industrial cooling use, which together account for practically all ground-water use in the Coastal Plain of southeastern Pennsylvania, are shown in Tables 2 and 3.

Table 2.—*U. S. Public Health Service standards for drinking-water supplies (abridged)*

(Source: U. S. Public Health Service, Reprint 2697, "Drinking Water Standards," 1946)

Constituent	*Maximum Permitted ppm*
Iron and manganese together	0.3
Magnesium	125
Sulfate	250
Chloride	250
Dissolved solids	500
	(1,000 permitted)

Table 3.—*Suggested limiting concentrations of certain constituents for cooling use.*

(Source: American Water Works Association, 1951, pp. 66-67. See also, California State Water Pollution Control Board, 1952, p. 134.)

Constituent or physical property	*Maximum ppm*
Turbidity	50
Hardness	50
Iron	0.5
Manganese	0.5
Iron and manganese	0.5

Iron is a particularly troublesome constituent because its occurrence is unpredictable with respect to both time and location. The occurrence of iron is influenced by a number of factors in the geochemical environment. For example, the concentration of ferrous ions in solution is largely controlled by the concentration of dissolved carbon dioxide which in turn is influenced by the temperature and pressure. Any change in these factors will be reflected in the concentration of iron. Similarly, the concentration of ferric hydroxide in colloidal suspension is dependent upon the presence of oxygen for the formation of the colloid and upon a number of other factors that may cause flocculation of the colloid. Thus the occurrence of iron is controlled by the local environment, and it commonly is impossible to trace the migration of iron from one area to another.

Physical Characteristics

From the standpoint of utility, temperature is the most important physical characteristic of ground water. The temperature of ground water fluctuates only slightly under natural conditions and is about equal to the temperature of the source rock. The rock temperature at shallow depths follows the daily and seasonal fluctuation of the air temperature, but the amplitude of the fluctuations decreases rapidly with depth and becomes negligible below a depth of 20 or 30 feet. The temperature near the base of the zone of seasonal fluctuation is commonly 2 or 3° F. higher than the mean annual air temperature of the region. Below that zone the earth temperature increases according to the geothermal gradient, which commonly averages about 1° F. for each 50 to 100 feet of depth.

Natural temperatures may be changed significantly by artificial factors. In areas where wells are supplied largely by induced infiltration from a surface source, the temperature of the ground water fluctuates in response to changes in the temperature of the surface supply. The use of wells for disposal of used water or other wastes also may cause appreciable fluctuations of the ground-water temperature, and heat transfer into the ground from large industrial installations may elevate considerably the temperature of shallow ground water in the immediate area.

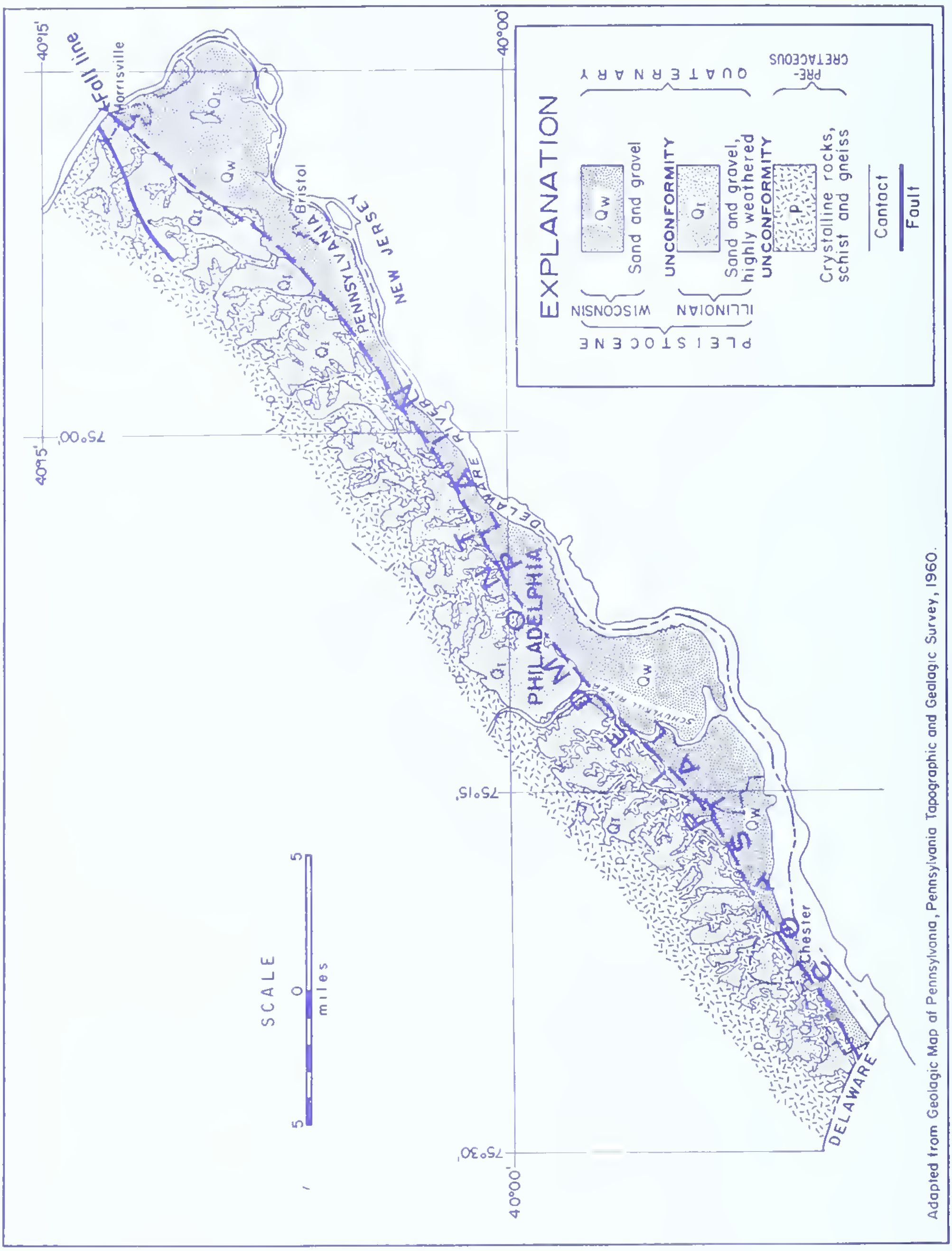

EXPLANATION
PLEISTOCENE
QUATERNARY
WISCONSIN
Qw
Sand and gravel
UNCONFORMITY
ILLINOIAN
Qt
Sand and gravel, highly weathered
UNCONFORMITY
PRE-CRETACEOUS
p
Crystalline rocks, schist and gneiss
Contact
Fault
SCALE
5 0 5
miles
Fall line
Morrisville
Bristol
PENNSYLVANIA
NEW JERSEY
DELAWARE RIVER
PHILADELPHIA
SCHUYLKILL RIVER
Chester
DELAWARE
40°15'
40°00'
75°00'
75°15'
75°30'
Adapted from Geologic Map of Pennsylvania, Pennsylvania Topographic and Geologic Survey, 1960.

Figure 2.

GROUND-WATER GEOLOGY

The geology of the Coastal Plain area of southeastern Pennsylvania is shown on the fence diagrams, Plates 3 and 4, which show the Quaternary and Cretaceous sediments that lie upon a basement of early Paleozoic rocks. Surface geology is shown on Figure 2.

The basement rocks are a complex assemblage of crystalline metamorphosed sedimentary and igneous rocks. These rocks rise to the surface at the Fall Line and are exposed in the Piedmont adjoining the northwestern margin of the Coastal Plain. Southeast of the Fall Line the crystalline rocks occur below unconsolidated deposits that increase in thickness southeastward.

The Cretaceous sediments are not exposed at the surface in the area of this investigation; however, information concerning them has been obtained from surface exposures in New Jersey and from cuttings and logs of borings and water wells in Pennsylvania. These sediments consist of highly permeable beds of sand and gravel separated by less permeable layers of clay and silt. The beds dip from 40 to 80 feet per mile to the southeast, forming a wedge-shaped mass that thickens toward the Atlantic Ocean.

Deposits of Quaternary age overlie the Cretaceous sediments and are exposed at the surface in many borrow pits. The Quaternary deposits consist predominantly of sand and gravel containing small amounts of silt and clay. These materials are distributed throughout the lower Delaware River valley as terraces and flood-plain deposits.

The succession and character of the rock formations underlying the Coastal Plain area are summarized in table 4. The stratigraphic nomenclature used in this report is the same as that used in previous reports except for the Raritan formation, which has been subdivided into six members instead of the seven introduced by Barksdale and others (1943) for a similar sequence of Raritan strata in Middlesex County, N.J. The geologic and hydrologic character of the formations are described in order of age from the oldest to youngest.

Pre-Cretaceous Rocks and their Water-bearing Characteristics

The pre-Cretaceous crystalline rocks of this area consist of mica and hornblende schists and gneisses. The age of these crystalline rocks was the subject of debate for many years. Bascom and others (1909a) and later Knopf and Jonas (1923, 1929) considered them to be Precambrian in age, but Hawkins (1924), followed by Mackin (1935), Miller (1935), and Cloos and Hietanen (1941), believed them to be early Paleozoic in age. Additional evidence in support of this latter view has been presented by Postel and Adelhelm (1943), Swartz (1948), Weiss (1949), Frondel (1951), and Watson and Wyckoff (1951). In 1957 the U.S. Geological Survey changed the age designation of these rocks from Precambrian (?) to Ordovician, on the basis of the lead-Alpha determinations of Postal and Jaffee (1957).

The pre-Cretaceous crystalline rocks are fine- to coarse-grained crystalline banded rock characterized by an excess of mica. The rocks comprise three distinct lithologies, including a hornblende gneiss, granite gneiss and a sequence of alternating micaceous schist and quartzite. The micaceous schist and quartzite are believed to represent a thick accumulation of arkosic and argillaceous sediments, and the hornblende and granite gneisses are generally considered to represent intrusive masses of mafic and felsic composition. The sedimentary and igneous materials were intensely metamorphosed by severe compressional forces into dense hard foliated rock.

Pre-Cretaceous crystalline rocks crop out northwest of the Fall Line and form the basement upon which the much younger Coastal Plain sediments were deposited. In the area immediately adjoining the Coastal Plain, the Crystalline rocks are alternately micaceous and quartzose. Cleavage and jointing are conspicuous and the color varies from yellowish gray to brownish black. The rock-forming minerals include quartz, feldspar, biotite, and muscovite with magnetite, apatite, zircon, tourmaline, garnet, and andalusite, sillimanite, and zoisite as accessory minerals.

Drill cuttings reveal that the buried upper surface of the crystalline rocks is marked by a residual clay. The upper few feet, or tens of feet, of the formation, have been weathered to a soft, gray extremely mica-

Table 4. *Generalized stratigraphic section of the Coastal Plain of southeastern Pennsylvania.*

System	Series	Formation and member	Symbol	Maximum Thickness (feet)	Physical character	Water-bearing character
Quaternary	Recent	Alluvium	Qal	72	Flood plain and channel deposits of clay, silt, sand, and some gravel.	Not important as a source of ground water; generally less permeable than underlying deposits; impedes the movement of water into and out of surface streams.
		Unconformity				
	Pleistocene	Cape May formation (Illinoian)	Qcm	80	Chiefly gray and brown sand and gravel; some silt; little clay. Cape May unweathered. Pensauken deeply weathered.	An important source of ground water in southeast Bucks County. Contains highly permeable sand and gravel beds which yield large quantities of water to wells. Favorably situated with respect to recharge; subject to surface contamination.
		Unconformity				
		Pensauken formation (Illinoian)	Qp			
		Unconformity				
Cretaceous	Upper Cretaceous	Magothy formation	Km	10	Medium to coarse gray sand with plant remains.	Unimportant as a source of water in Pennsylvania owing to its small aerial extent.
		Unconformity				
		Upper clay member	Kru	35	Chiefly red, white, gray, and yellow clay. Also brown and blue clay; silty, sandy, and pebbly in places.	Acts chiefly as a confining bed.
		Unconformity				
		Raritan formation: Old Bridge sand member	Kro	55	Chiefly brown, gray, white, and yellow sand with some gravel; contains some clay and silt in Bucks County.	An excellent aquifer; forms an extensive water table aquifer interconnected with the Pleistocene sediments. Generally not tapped by wells in areas where it occurs beneath an upper confining bed.
		Unconformity				
		Raritan formation: Middle clay member	Krm	60	Chiefly red and white clay; also gray, yellow, blue, and brown clay; sandy in places.	An extensive confining bed.
		Unconformity				
		Raritan formation: Sayreville sand member	Krs	49	Chiefly brown, yellow, white, and gray sand and gravel; little clay.	Generally not tapped by wells. Potentially an important aquifer in Bucks County.
		Unconformity				
		Raritan formation: Lower clay member	Krl	60	Chiefly red clay, also gray, blue, white, and brown clay; sandy in places.	An extensive confining bed.
		Unconformity				
		Raritan formation: Farrington sand member	Krf	87	White, yellow, gray, and brown sand and gravel; some white clay.	The principal source of ground water in the Philadelphia area; average permeability 1,000 gpd per sq. ft. as determined by pumping tests. Yields from 500 to 1,000 gpm to wells in South Philadelphia.
		Unconformity				
Pre-Cretaceous	Glenarm	Crystalline rocks	p	?	Mica schist capped by residual weathered clay.	Poor aquifer in the Coastal Plain area; contains some ground water in secondary fractures; average yield less than 50 gpm.

ceous clay that becomes firmer and more granular with increasing depth. Beneath the partly disintegrated zone the parent rock is a medium to coarsely crystalline, well-foliated mica schist.

Although the crystalline rocks comprise a variety of rock types, the different lithologies have little if any effect upon their water-bearing properties. All are dense, crystalline rocks which in their unaltered state are virtually impervious to water. However, like most consolidated rock formations, they are broken by joints and other fractures as a result of weathering and deformation. These openings constitute only a small part of the total rock volume, but they provide for the storage and movement of considerable quantities of water.

The openings which contain ground water are most abundant in a relatively shallow zone of rock material near the land surface where the forces of weathering are most effective. Beneath this zone the number and size of such openings decrease rapidly as the weathered material grades into unaltered rock. The weathered zone is thickest in areas of low to moderate relief and is thin or absent in areas of high relief. The unweathered zone apparently rarely extends below a depth of about 150 feet because the yields of wells are seldom increased by drilling below that depth. A few wells, however, are reported to obtain appreciable amounts of water below depths of 150 feet.

Based on the records of drilled wells in the Coastal Plain area (table 11) the crystalline rocks are a reliable source of small to moderate supplies of ground water. The reported yields of 74 wells range from 1 to 350 gpm and average 65 gpm. The specific capacity of wells tapping these rocks, based on data from 42 wells, ranges from 1 to 8 gpm per foot of drawdown and averages 3 gpm per foot of drawdown.

In the outcrop area of the crystalline rocks ground water generally occurs under water-table conditions. Locally, water under artesian conditions may be expected in areas where open fractures in the crystalline rocks occur beneath the weathered zone and the confining beds of the overlying sediments.

The widespread residual clay at the top of the crystalline rocks probably serves as a confining bed where it occurs below the overlying unconsolidated sediments. This is evident from available water-level data which show a difference in head between water in the crystalline rocks and that in the unconsolidated material immediately above the

contact. Where the confining bed is continuous the head in the crystalline rocks has a relatively steep gradient to the southeast away from the Fall Line. This gradient is interrupted wherever the confining bed is breached, and where this occurs the head in the crystalline rocks and the unconsolidated aquifers is about the same.

Configuration of the Erosion Surface on the Buried pre-Cretaceous Rocks

The configuration of the erosion surface on the pre-Cretaceous rocks beneath the Coastal Plain sediments is that of a southeast-dipping surface channelled by the ancestral Schuylkill and Delaware Rivers. (See Pls. 5 and 6.) These ancient valleys are important because they contain thick accumulations of highly permeable, coarse-grained sediments of Cretaceous age, which comprise the most reliable and productive sources of ground water in the area.

The ancestral Schuylkill River is represented by four south to southeast-trending channels carved in the crystalline rock floor beneath south Philadelphia. These are from south to north the Point Breeze, League Island, Greenwich Point, and Washington Square troughs (Pl. 5). These troughs underlie the major areas of ground-water development in Philadelphia County.

The ancestral Delaware River valley can be projected below the Coastal Plain sediments in Bucks County as a narrow depression trending south-southwest from the Pennsylvania Railroad bridge at Trenton, N. J. (Pl. 6). The buried valley cuts across Biles Island, and passes beneath the present channel of the Delaware River near the eastern tip of Neubold Island. As evidenced by subsurface data the ancestral valley floor descends more than 150 feet between the bridge at Trenton and the Victor Chemical water well (Bk-629) at Morrisville, 1.1 miles to the south. Here the ancestral Delaware River apparently cascaded over a series of steep rapids or a high waterfall.

Numerous other streams tributary to the ancestral Delaware River were integrated into the pre-Cretaceous drainage pattern. These include Bristol Run, Florence Run, Tullytown Run, Scottscreek Run, Moon Island Run, and Turkey Hill Run in Bucks County (Pl. 6), and Frankford Creek in Philadelphia County (Pl. 5). Most of the tributaries flowed in a south-southeasterly direction with the exception of a few such as Turkey Hill Run, Florence Run, and Moon Island Run, which flowed in an easterly direction.

Cretaceous Rocks and their Water-bearing Characteristics

The oldest sediments to accumulate in the channels carved into the basement rocks consist of fluvial and estuarine deposits that are believed to be of Late Cretaceous age. These sediments have been subdivided into the Raritan and Magothy formations.

Raritan Formation

The name Raritan first was applied to a sequence of nonmarine plastic clay beds and intervening sand deposits exposed in central New Jersey near Raritan Bay (Cook 1888). Clark (1904) restricted the Raritan formation to the lower part of the nonmarine sequence because he believed the uppermost beds, which he called the Magothy formation, to be transitional into the overlying marine sediments. As thus defined the Raritan formation consists of alternating beds of nonmarine clay, sand, and gravel that occupy the stratigraphic interval between the consolidated pre-Cretaceous rocks below and the Magothy formation above. In the type locality the Raritan formation can be readily differentiated from the overlying Magothy formation on the basis of faunal and lithologic evidence. Elsewhere, the distinction between these formations is based on less convincing evidence, usually the abundance of lignitic material in the Magothy.

The outcrop area of the Raritan formation occupies a nearly continuous narrow belt adjacent to the Fall Line from Long Island, N. Y., southwestward through the Delaware River valley to the Potomac River in Maryland (Richards, 1945). The formation extends southeastward below the surface of the Coastal Plain. The outcrop area is widest in New Jersey where the formation is approximately 350 feet thick. The Raritan formation decreases in thickness, along the strike, to around 200 feet in the Delaware Valley and to less than 100 feet in Maryland.

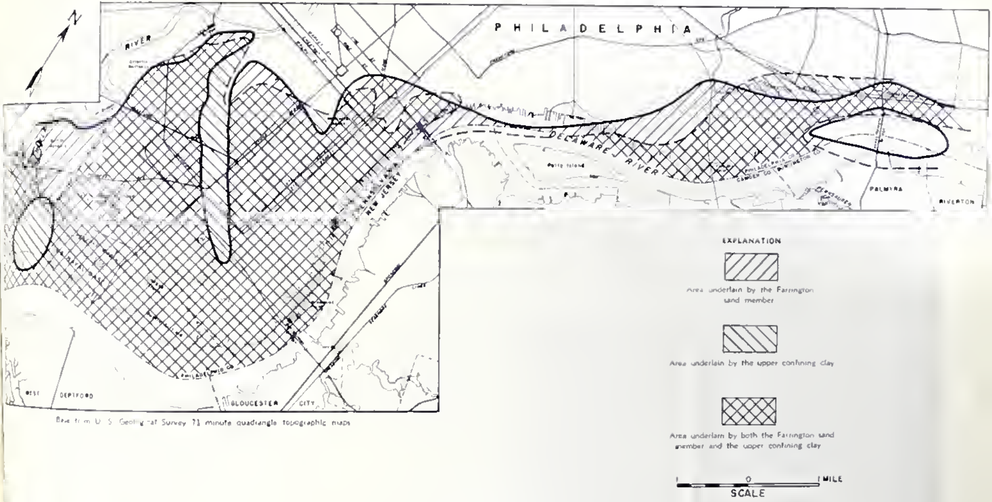
In Pennsylvania the Raritan formation consists of a sequence of nonmarine deposits representing three cycles of sedimentation. Each cycle begins with a series of coarse detrital deposits and closes with a series of silts and clays. This sequence of strata duplicates, in most respects, the section exposed in the type locality in New Jersey where the Raritan was subdivided by Barksdale and others (1943) into seven members. In ascending order these members in New Jersey are the

Raritan fire clay, the Farrington sand, the Woodbridge clay, the Sayreville sand, the South Amboy fire clay, the Old Bridge sand, and the Amboy stoneware clay. Each of these members can be correlated with equivalent units in Pennsylvania with the exception of the lowermost member, the Raritan fire clay, which is not recognized because the clay which occupies the same stratigraphic interval in the Pennsylvania section is believed to represent a residual clay derived from the mechanical disintegration of the underlying crystalline rocks. The names formally applied to the three sand members in the type locality have been adopted for use in Pennsylvania. In this report the three clay members given will be called, in ascending order, the lower, middle, and upper clay members. Therefore, in ascending order, the members of the Raritan formation in Pennsylvania are the Farrington sand, the lower clay, the Sayreville sand, the middle clay, the Old Bridge sand, and the upper clay. The correlation of the six members is based solely upon the similarities in texture and sequence of Raritan strata in Pennsylvania and New Jersey and does not mean, necessarily that the individual strata can be traced as continuous lithologic units between the two areas.

The occurrence, texture, thickness, stratigraphic relations, and water-bearing properties of each of the members is discussed in the following sections.

Farrington sand member

The Farrington sand member is the basal member of the Raritan formation in Pennsylvania and occupies the lowermost part of the pre-Cretaceous channels carved into the underlying crystalline rocks. Plates 7 and 8, which were compiled from all available subsurface information, indicate by means of contours the extent and position of the Farrington sand member in the subsurface of the Coastal Plain. As shown by these maps, the Farrington sand member occurs in and on the margins of five troughs in the Philadelphia area and to a lesser extent in and on the margins of four troughs in southeast Bucks County. The occurrence or absence of the Farrington sand member in the Philadelphia area (Pl. 7) is well documented by data from about 200 water wells. In Bucks County, however, the occurrence of the Farrington is inferred largely from the depth of the buried pre-Cretaceous drainage system and the known position of the sand in the subsurface of adjoining parts of New Jersey.



Base from U. S. Geological Survey 7½ minute quadrangle topographic maps

Figure 3
Map showing the area in Philadelphia underlain by the Farrington sand member of the Raritan formation and its overlying confining area

The Farrington sand member consists predominantly of coarse sand and fine gravel which grade upward into medium- to fine-grained sand containing a few beds of white clay. The color of the sand varies from yellowish gray to pale yellowish brown. However, the material is most often described by drillers as clean white sand. Generally, the coarse sand and fine gravels are fairly well sorted but not so well sorted as the finer-grained materials. On the other hand, the roundness of the grains seems to improve with the size of the material — ranging from subangular for the smallest sized particles to well rounded for the largest. Typical descriptions of the Farrington sand member are given in the sample well logs for the Philadelphia area (Table 13).

The thickness of the Farrington sand member differs greatly from place to place, as shown by the isopachous maps of the member in Philadelphia and Bucks Counties (Pls. 9 and 10). The member is thickest in the axial parts of the troughs and thins rapidly toward the margins. The sand attains a maximum thickness of approximately 90 feet near the mouth of the League Island trough, but in most areas of occurrence in Pennsylvania it rarely exceeds 60 feet in thickness.

Throughout most of its area of occurrence the Farrington sand member is overlain by either the lower or middle clay members of the Raritan. (See fig. 3.) Near the heads of the troughs of deposition, however, these clay members have been removed by erosion, and the Farrington sand member is overlain directly by either the Old Bridge sand member of the Raritan formation or the Cape May formation of Pleistocene age.

The Farrington sand member is an important aquifer in the Coastal Plain area of Pennsylvania. It is generally overlain by the thick persistent clays, which act as confining beds — insulating the member from overlying water-bearing beds and from surface-water sources. As a result it functions as a separate hydrologic unit, having distinct hydraulic head and characteristic water-bearing and quality-of-water properties. In a few places the confining clays are absent, and the Farrington sand member is hydraulically continuous with overlying water-bearing beds. Where this occurs water is free to move from one aquifer to another, and the Farrington sand member loses its identity as a distinct hydrologic unit.

Records of wells which tap the Farrington sand member in the report area are included in the tabulation of well records (Table 11). The report yields of 136 wells range from 30 gpm (Ph-103) to 1,350 gpm (Ph-467) and average about 400 pgm. In general, the largest yields are obtained from wells that penetrate the relatively thick deposits of Farrington sand member in axial parts of the Point Breeze, League Island, and Greenwich Point troughs in south Philadelphia. Typical wells in those areas penetrate from 40 to 90 feet of the Farrington member and yield from 700 to 1,100 gpm. Elsewhere the Farrington sand member is thinner and yields of wells are correspondingly lower. For example, in the Washington Square trough wells penetrate a maximum of about 25 feet of the Farrington sand member, and yields rarely exceed 400 gpm. Similarly, yields of less than 250 gpm are common from the Farrington near the Schuylkill River where the member is generally less than 15 feet thick.

Reported yields provide only a crude but conservative estimate of the water-yielding capacity of the aquifer because few wells are screened through the entire thickness of the Farrington sand member, and many wells are not developed and tested to maximum capacity. The specific capacity of a well is a more accurate index of the water-bearing character of the aquifer because it takes into account the factor of drawdown. Specific-capacity data are useful also for comparative purposes because they equate the yields of wells to a common basis. Yields and specific capacities of typical wells screened in the Farrington sand member are summarized in Table 5.

Table 5.—*Data on the water-yielding capacity of some industrial wells screened in the Farrington sand member of the Raritan formation.*

Well no.	Thickness of aquifer (feet)	Length of screen (feet)	Reported yield (gpm)	Specific capacity (gpm per foot of drawdown)
Ph-4	60	30	800	30
Ph-7	17	15	710	6
Ph-25	45	30	1,200	12
Ph-407	41	30	1,035	25
Ph-408	35	40	1,050	27
Ph-417	16	15	726	16
Ph-418	21	15	776	17
Ph-419	17	15	744	17
Ph-420	29	15	709	23
Ph-423	17	15	300	4
Ph-451	35	30	1,080	25
Ph-452	50	30	1,100	37
Ph-457	27	20	620	14
Ph-458	31	25	715	16
Ph-459	38	25	743	21

Pumping tests were made on seven wells to determine the coefficients of transmissibility and storage for the Farrington member in the vicinity of Philadelphia. The results of the tests are summarized in Table 6.

The relatively wide range in the coefficients of transmissibility and storage is due chiefly to the heterogeneity of the aquifer and to differences in its thickness. Thickness apparently is important because the coefficients of permeability, which are independent of thickness, are in fairly close agreement. The average coefficient of permeability determined from tests in the League Island trough, (tests A-E and G, Table 6), is about 1,000 gpd per square foot. This corresponds to the results obtained from nine pumping tests in the Farrington member at nearby locations in New Jersey (Barksdale and others, 1958).

Table 6.—*Results of pumping tests made on the Farrington sand member of the Raritan formation.*

Pumping test	Date	Pumped well	Observation well	Discharge (Gpm)	Average effective sand thickness (feet)	Transmissibility (gallons per day per foot)	Permeability (gallons per day per square foot)	Storage co-efficient
A	1-11-47	Ph-1	Ph-3	920	65	60,000	920	.00007
B	12-18-47	Ph-3	Ph-1	1,050	60	56,000	930	.00007
C	1- 3-48	Ph-2	Ph-18	550	60	55,000	920	.0002
		Ph-2	Ph-19	550	60	59,000	980	.0002
D	1- 5-48	Ph-1	Ph-19	580	60	62,000	1,030	.0002
E	1- 7-48	Ph-4	Ph-3	800	60	68,000	1,130	.00009
F	12-15-49 and 12-16-49	Ph-417	Ph-419 Ph-420	500	20	21,000	1,050	.00008
G	11- 2-50	Ph-140	Ph-139	375	20	21,000	1,050	.0008

The hydraulic coefficients obtained from pumping tests can be used to predict the long-term yields of wells and the behavior of water levels in the test areas in response to known conditions of recharge and discharge. They should not be extrapolated, however, to predict the effects of withdrawals in other areas or to describe the regional hydraulic characteristics of the Farrington member because those characteristics differ markedly from place to place.

The coefficients of transmissibility and storage and the thickness of the aquifer can be used to provide a rough estimate of the potential specific capacity of a proposed well. The theoretical relationship between specific capacity and aquifer thickness can be derived from Jacob's (1950, p. 372) equation for specific capacity, which is based on an approximation of the Theis nonequilibrium formula (Theis, 1935). By using average values for permeability and storage coefficients, and assuming certain standard conditions of effective well radius, length of pumping, and entrance loss, a theoretical average specific capacity for an aquifer can be computed. The theoretical relationship between specific capacity and thickness of the Farrington sand member, assuming an average permeability of 1,000 gpd per ft^2 and a storage coefficient of 1×10^{-6} (see Table 6), after 24 hours of pumping from a 12-inch diameter well that is assumed to be 100 per cent efficient is shown on Figure 4.

The points plotted on Figure 4 represent known aquifer thicknesses and reported specific capacities for all wells for which reliable data are available. Factors that contribute to the scattering of the data about the theoretical line are local differences in permeability of the Farrington member and of the confining clay, differences in the diameter of the wells and the periods of pumping, and human errors in recording the test data. Another factor, which is constant in effect, is that no well can be developed to 100 percent efficiency; this is believed to account in part for the fact that most of the field data plot to the left of the vertical curve.

It should be emphasized that the theoretical relationship between specific capacity and thickness shown in Figure 4 is based on the assumption that the aquifer consists of a single confined sand of uniform thickness, large areal extent, constant permeability, and a uniform storage coefficient. Nonetheless, the graph can be used to estimate specific capacities throughout most of the area of occurrence of the Farrington sand member using the thicknesses of the Farrington

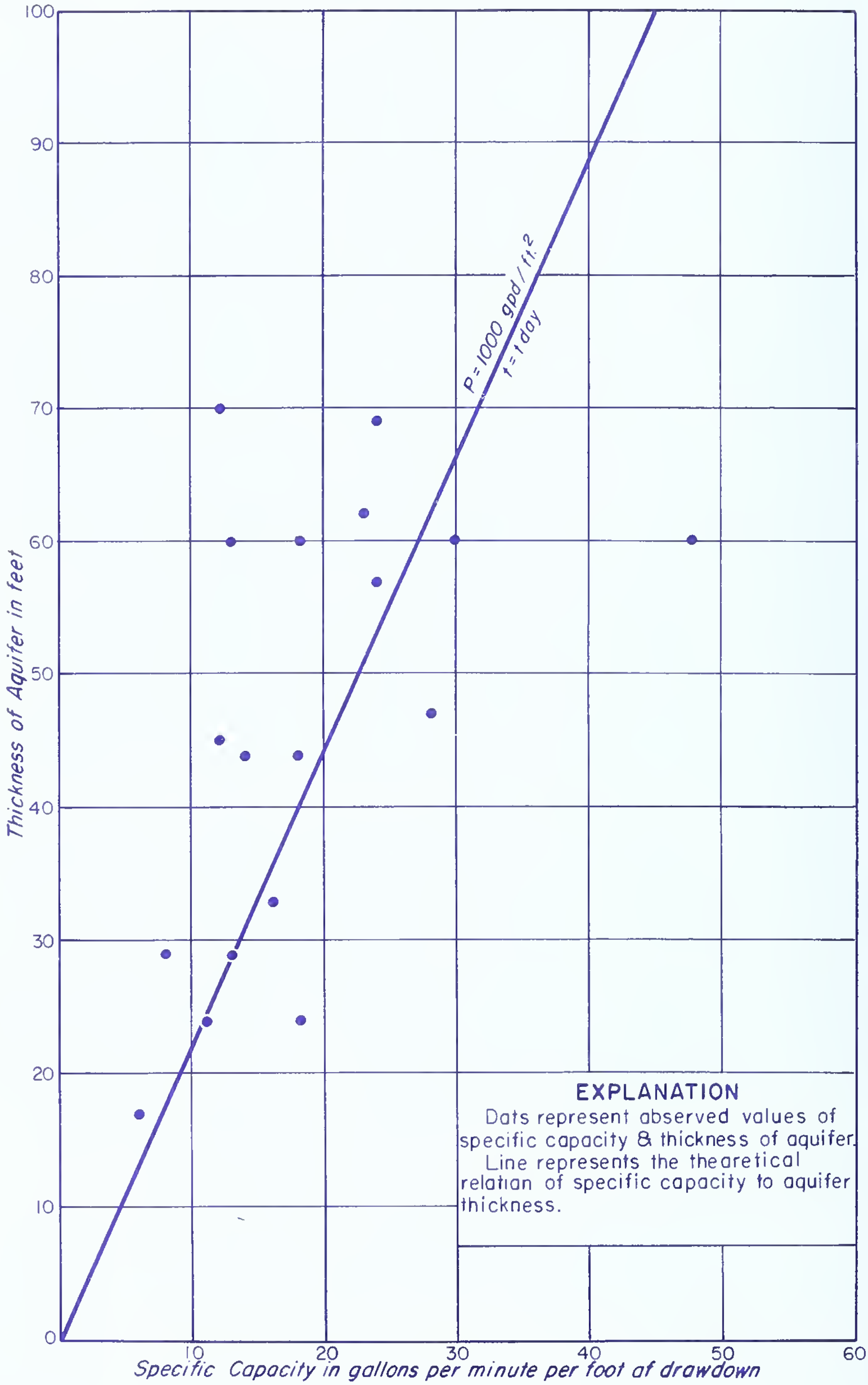


Figure 4.

Graph showing theoretical and observed relations of specific capacity to the thickness of the Farrington sand member of the Raritan formation in the League Island trough.

shown on the isopachous maps (Pls. 9 and 10). Specific capacities predicted from Figure 3 should be used with caution, although they provide more reliable estimates for unproved sites than can be obtained from any other known method.

Lower clay member

The lower clay member is composed mainly of tough clay continuous bed of clayey material separating the underlying Farrington sand member from the overlying Sayreville sand member. The subsurface position and distribution of the lower clay is shown schematically in Plates 3 and 4. The distribution of the lower clay in the subsurface of Bucks County is shown by means of a contour map of its upper surface (Pl. 11).

In general, the lower clay occurs in the same bedrock channels as the Farrington sand member, but the distribution of the clay is somewhat different. Along the margins of the troughs the clay, as a rule, overlaps the sand, but near the heads of the troughs the Farrington extends beyond the limits of the lower clay. The absence of the lower clay near the heads of the troughs is ascribed to stream erosion immediately following the deposition of the clay.

The lower clay member is composed mainly of tough clay containing beds of soft, well-stratified clay and thin lenses of fine-grained sand. The tough clays are brick red in color in contrast to the gray color of the softer materials. Although the texture and composition of the materials comprising the lower clay are fairly uniform, the sequence and thickness of beds penetrated by individual wells show considerable variation. Typical sections of the lower clay are shown in the wells Ph-2, Ph-19, and Ph-22 (Table 13).

The lower clay rests unconformably upon either the Farrington sand member or the residual clay of the crystalline— rock floor. The contact is easily recognized in both instances owing to the differences in texture and composition of the materials of the different units. Similarly, the upper contact of the member is distinct where the clay is directly overlain by the Sayreville sand member of the Raritan. In certain parts of south Philadelphia, however, the Sayreville sand is absent and it is difficult to identify the contact because the clays are nearly indistinguishable in the subsurface.

The thickness of the lower clay member differs from place to place owing in part to the irregularities of the surface upon which it was deposited. It ranges from 0 to 61 feet at the mouth of the League Island trough. For the most part, however, the thickness ranges between about 20 and 40 feet. The differences in thickness of the clay are illustrated by the isopachous map of the member in southeastern Bucks County (Pl. 12) and the fence diagrams (Pls. 3 and 4). No attempts were made to prepare an equivalent map for south Philadelphia because in much of that area the lower clay cannot be separated from the immediately overlying middle clay member. (See Table 13, well Ph-68.)

Although the lower clay member is not an aquifer it is an important hydrologic unit in the Coastal Plain. Where present it functions as a confining bed between the Farrington and Sayreville members, preventing free movement of water between these aquifers.

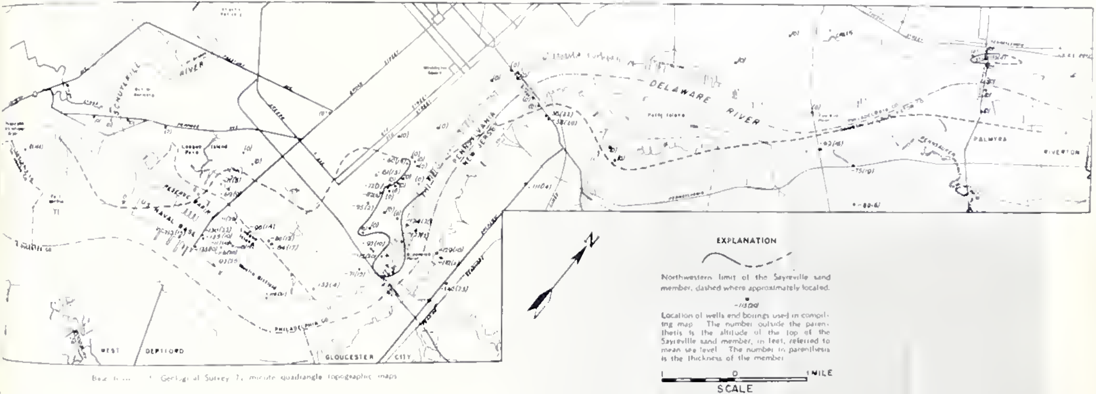
Sayreville sand member

The Sayreville sand member occupies the stratigraphic interval between the underlying lower clay and the overlying middle clay. In the type locality near Sayreville, N. J., it is identified as "the number two sand" of the Raritan formation, in deference to the basal Farrington sand member.

The Sayreville sand underlies the southern part of the city of Philadelphia as well as southeastern Bucks County. In the southern part of Philadelphia it is not an extensive deposit. (See Fig. 5).

It occupies shallow channels cut into the lower clay and extends scarcely more than 1 or 2 miles northwestward from the Delaware River.

Details of the occurrence and distribution of the Sayreville sand member in southeastern Bucks County are shown on Plate 13. In this area the sand extends as much as 4 miles northwestward from the Delaware and occurs as broad, valley-filling deposits separated by narrow bedrock divides. The surface of the sand lies at approximately 120 feet below sea level at its lowest point along the Delaware River and rises to a maximum altitude of about 20 feet above sea level near the Fall Line.



Base from U.S. Geological Survey 7½ minute quadrangle topographic maps

Figure 5.
Map of the Philadelphia area showing extent of the Sayreville sand member of the Raritan formation

The Sayreville member consists of a sequence of light-colored very fine- to coarse-grained sand beds and a few beds of light-gray clay. The predominant color of the sand is pale yellowish brown to orange. most of the sediments are fairly well sorted and the grains are commonly subangular to subrounded. Characteristically, the nominal grain size decreases away from the heads of the depositional troughs, indicating the relative direction of movement of the depositing medium. Although the Sayreville is a presistent depositional unit, the sequence of beds penetrated by individual wells is not altogether uniform from place to place. This suggests that the material was deposited in lens-shaped masses by shifting currents. Typical descriptions of the Sayreville are shown in the logs of wells Ph-19 and Bk-676 and test holes B-170, B-174, B-176, and B-195 in Table 13.

The thickness of the Sayreville sand member ranges from 0 to a maximum of 49 feet. Differences in the thickness of the Sayreville in Bucks County are shown on the isopachous map of the sand in that area (Pl. 14). Generally the thickness is greatest near the axes of the troughs. In the Philadelphia area the Sayreville has a maximum thickness of about 25 feet, but the sand is commonly less than 20 feet thick.

The hydrologic relationships of the Sayreville sand member are similar in many respects to those of the Farrington sand member. In south Philadelphia the Sayreville sand member is the "middle" aquifer of Graham and Kammerer (1952). In south Philadelphia it occurs as a distinct hydrologic unit confined between persistent clay confining beds that separate it from overlying and underlying water-bearing beds (Pl. 3). But in Southeastern Bucks County the Sayreville sand member is not completely isolated from other aquifers because the overlying clay bed is replaced in a few places by the Old Bridge sand member and younger channel-fill deposits of Pleistocene age. Where the channel fills occur, the Sayreville member is presumed to be hydraulically continuous with overlying water-bearing beds with which it probably functions as a single hydrologic unit.

The water-bearing properties of the Sayreville sand member are imperfectly known chiefly because it is tapped by only a few wells in the Coastal Plain area. All of the data available on the reported yields and tested specific capacities of wells screened in the Sayreville sand member are summarized in Table 7. These data are not adequate to describe fully the hydraulic properties of the Sayreville

sand member, but they provide a basis for a rough estimate of these properties. Comparison of well data given in Table 7 for the Sayreville sand member with those in Table 5 for the Farrington sand shows that on the average the ratio between aquifer thickness and specific capacity is about the same for the two members. It is probable, then, that the average permeability of the members is about the same; however, the average transmissibility of the Sayreville member probably is less than that of the Farrington member because the average thickness of the Sayreville is less than that of the Farrington.

Table 7.—*Data on the water-yielding capacity of industrial wells screened in the Sayreville sand member of the Raritan formation.*

Well no.	Thickness of aquifer (feet)	Length of screen (feet)	Reported yield (gpm)	Specific capacity (gpm per foot of drawdown)
Ph-10	10	7	350	6
Ph-12	27	....	....	13
Ph-30	44	20	575	36
Ph-154	10	3	100	2
Ph-496	17	10	750	16
Bk-531	17	22	500	17
Bk-533	20	20	480	....
Bk-540	40	40	300	8
Bk-546	18	20	775	24
Bk-551	18	10	150	10
Bk-633	47	0	95	....
Bk-634	10	10	300	....
Bk-635	13	13	90	....
Bk-636	13	13	170	....

Middle clay member

The middle clay is the most extensive clay member of the Raritan formation in Pennsylvania. Details of its areal distribution and subsurface position are shown by the contour maps of the upper surface of the member (Pls. 15 and 16). The surface of the clay is characterized by several elongated depressions oriented parallel to the

trend of the underlying bedrock channels. Most of these irregularities are believed to be due to erosion which occurred contemporaneously with the deposition of younger deposits. A nearly uniform slope of approximately 40 feet per mile to the southeast is discernible where the surfaces of the clay is least channelled. This slope probably approximates the attitude of the strata composing the member.

The lithology of the middle clay is much less variable than that of other clay members of the Raritan formation. For the most part the member is composed of tough, red and white clay with a uniformly massive texture. It commonly contains relatively little sandy material, but a few thin streaks or lenses of fine-grained sand have been noted, particularly in its middle and upper parts. Locally the base of the member is marked by a conspicuous bed of lignite. In general, the top and bottom of the clay in the subsurface can be identified readily from well logs except where the member lies directly upon other Raritan clays. In such places it is difficult to distinguish the contacts because of the lithilogic similarity of the indivdual clay members.

The thickness of the middle clay, similarly to that of the lowest clay, differs considerably from place to place owing to irregularities in the erosional surfaces that occur above and below the member. Within the area of this investigation the thickness commonly exceeds 20 feet and ranges from 0 to about 60 feet. Variations in the thickness of the member beneath Bucks County are shown in Plate 17.

In the Philadelphia area the middle clay lies directly upon the lower clay from which it cannot be differentiated. The combined thickness of the lower clay, Sayreville sand, and middle clay is shown in Plate 18.

The middle clay has an extremely low permeability and serves as an effective barrier to the movement of ground water. In Bucks County it contributes to artesian conditions in the underlying Sayreville sand member. Where the Sayreville is absent in the Philadelphia area, the middle clay merges with the lower clay to form the thick confining bed of the Farrington sand member, the principal aquifer in that area.

Old Bridge sand member

The Old Bridge sand member unconformably overlies the middle clay. Although it does not crop out in Pennsylvania, the Old Bridge sand underlies much of the Coastal Plain area in southeast Bucks County and, to a lesser extent, in south Philadelphia County. For the most part, the Old Bridge occupies erosional depressions or scour channels in the underlying middle clay (Pls. 15 and 16). Apparently the Old Bridge sand member was deposited by the same streams that scoured the channels in the clay; hence, it is assumed that erosion of the clay took place contemporaneously with the deposition of the sand. In a few localities the underlying middle clay was completely removed and the Old Bridge was deposited directly upon deposits older than the middle clay.

The Old Bridge sand member consists mainly of medium- to coarse-grained sand and contains minor amounts of fine to very fine sand. Beds of gravel are common, particularly at the base of the member. The predominant color is light gray to yellowish brown. In general, the material comprising the Old Bridge is fairly well sorted and individual grains appear to be angular or subangular. Typical sections of the Old Bridge sand member are described in the logs for wells Ph-1, Ph-68, and Bk-676. (See Table 13.)

The thickness of the Old Bridge sand member is greatest along the axes of the depressions in which the sand accumulated. Away from these axes the thickness gradually diminishes until the sand pinches out. In south Philadelphia County the Old Bridge attains a thickness of over 50 feet beneath League Island and in the vicinity of Greenwich Point. Elsewhere it rarely exceeds 35 feet except near Turkey Hill in Bucks County where as much as 100 feet of sand has tentatively been identified as Old Bridge (Lockwood and Meisler, 1960).

Although the Old Bridge is sufficiently porous and permeable to store and transmit considerable quantities of ground water, it is not a distinct hydrologic unit in the Coastal Plain of Pennsylvania. Throughout most of the area of its occurrence, it forms a hydraulically continuous unit with overlying deposits of sand and gravel of Pleistocene age, and the Old Bridge sand member and the Pleistocene sediments function as a single aquifer in spite of the difference between their ages. The water-bearing properties of the aquifer formed by these two units are discussed in the section on Pleistocene sediments.

Upper clay member

The upper clay is the uppermost member of the Raritan formation. It is not an extensive deposit in Pennsylvania, but it does occur in the subsurface in a few localities in south Philadelphia and in Bucks County (Pls. 3 and 4). Where the upper clay is present in subsurface it overlies the Old Bridge sand member, separating the latter from the overlying Pleistocene deposits (or from the Magothy formation if it is present).

The upper clay attains a thickness of 35 feet in south Philadelphia and 25 feet in Bucks County. It consists of light gray, more or less sandy clays; dark gray carbonaceous clays; and massive, red, white, and yellow clays. The various types of clay do not occur in any regular sequence or combination. Typical sections of the clay are shown in the logs of wells Ph-10, Ph-19, and Bk-676. (See Table 13.)

The upper clay is not an important hydrologic unit in Pennsylvania because of its small areal extent. Where it is present it doubtless contributes to local artesian conditions in the underlying Old Bridge sand because it separates the Old Bridge from the overlying sands and gravels of Pleistocene age.

Magothy formation

The Magothy formation, of Late Cretaceous age, overlies the Raritan formation. The name was first proposed by Darton (1893) for the white and buff-colored sands that are exposed along the Magothy River in Anne Arundel County, Md. The formation is well exposed in the Coastal Plain of New Jersey where it consists of alternating beds of dark clay and light sand and is commonly lignitic (Bascom and others, 1909b).

In Pennsylvania the Magothy formation is not exposed at the surface, but it has been tentatively identified in the subsurface in Bucks County and is believed to pinch out northwestward. (see Pl. 4) According to the log of well Bk-676 (Table 13) the formation consists of medium- to coarse-grained gray sand that contains plant remains. The Magothy is underlain by the upper clay member, but where the latter has been eroded away it is underlain by the Old Bridge sand.

The Magothy formation is not an important hydrologic unit in Pennsylvania because it has a very small areal extent.

Quaternary Rocks and their Water-bearing Characteristics

Pleistocene Deposits

The Cretaceous sediments of the Coastal Plain of Pennsylvania are completely buried by Pleistocene deposits consisting mainly of sand, gravel, and clay. These Pleistocene deposits were subdivided by Salisbury (1898) into the Bridgeton, Pensauken, and Cape May formations; the Bridgeton is the oldest of the three and the Cape May is the youngest. These formations are differentiated largely on the basis of their topographic position. The Bridgeton occurs as remnants of a terrace at an altitude of between 110 and 175 feet above sea level; the Pensauken underlies the terrace level that stands between 20 feet below and 120 feet above sea level; and the Cape May formation occurs chiefly in the lowland along the Delaware River, at an altitude of less than 30 feet above sea level. Deposits previously mapped as Pensauken on the Pennsylvania part of the Trenton quadrangle (Bascom and others, 1909b, areal geology map) have been mapped by Peltier (1959) as Illinoian valley train sand and gravel. Peltier (1959) identified as Wisconsin in age, the sediments previously mapped as Cape May by Bascom and others (1909b, areal geology map). Lockwood and Meisler (1960) subdivided the Pleistocene in the Coastal Plain of Bucks County into Wisconsin and Illinoian stages, which are separated by a period of weathering and erosian corresponding to the Sangamon interglacial stage.

The subdivision of the Pleistocene into Wisconsin and Illinoian stages is used in this report. Figure 2 shows the areal extent of sediments of Wisconsin and Illinoian age in the Coastal Plain and adjacent parts of the Piedmont in Pennsylvania.

In Philadelphia County the maximum thickness of the Pleistocene deposits is about 80 feet and the typical thickness is about 40 feet. (see Pls. 3 and 4.) Along the Delaware and Schuylkill Rivers most of the Pleistocene deposits have been removed by erosion. The dominant material is brown to gray sand and gravel composed of medium- to coarse-grained, angular-to-rounded quartz sand grains, and pebbles and boulders of sandstone, siltstone, chert, quartzite, and mica schist.

In Bucks County the maximum thickness of the Pleistocene deposits is about 60 feet and the typical thickness is about 30 feet. The

deposits of Wisconsin age consist of poorly sorted gray sand and gravel comprising materials ranging in size from fine-grained sand to glacial erratics weighing several hundred pounds. The pebbles and boulders are hard sandstones, quartzite, red and gray argillites, gray silty limestones, gneisses, and gray granitic-textured igneous rock. Many of the boulders are soled and show strong glacial striae. The glacial character of the deposits becomes progressively less apparent down the Delaware River valley toward Philadelphia.

The older sediments, of Illinoian age, are intensely weathered compared to the Wisconsin sediments. Glacial erratics composed of weathered boulders of granite, gneiss, sandstone, siltstone, and quartzite and weighing as much as several hundred pounds are found in the Illinoian in the Morrisville area. The quartzite boulders have flattened solelike surfaces on which faint glacial striae are common.

The following descriptions are typical of the Pleistocene sediments in Bucks County. At Edgely, 7 feet of Wisconsin gray gravel and silt overlie 17 feet of Illinoian brown gravel and sand. South of Tullytown, 18 feet of Wisconsin sand and gravel overlie 20 feet of Illinoian brownish-gray silt and sand. On the west shore of Scott Creek, approximately one-half mile north of the Delaware River, 8½ feet of Wisconsin sand and gravel overlie 15 feet of Illinoian brown sand. North of Wheat Sheaf, 8½ feet of Wisconsin gray gravel and sand and brown silt overlie 10 feet of Illinoian coarse sand and fine gravel. At Turkey Hill there is 30 feet of Wisconsin sand, gravel, cobbles, and boulders and 43 feet of Illinoian sand, gravel, and silt. North of Penn Valley, Wisconsin deposits have been eroded away, and 15 feet of Illinoian gravel and coarse sand remain. On the north shore of the Delaware River, near the west edge of Neubold Island, 15 feet of Wisconsin gravel and brownish-gray sand overlie 18 feet of yellowish-brown coarse sand and fine gravel of Illinoian age.

The Pleistocene deposits, together with the underlying Old Bridge sand member of the Raritan formation, comprise the most extensive aquifer in the lower Delaware River Valley in Pennsylvania. This aquifer is underlain by the middle clay member of the Raritan formation. The Pleistocene deposits are extremely heterogeneous, consisting of a wide assortment of grain sizes including considerable amounts of fine-grained clayey material. As a result, the water-bearing properties

of the aquifer are far from uniform. In general, the best water-bearing materials in the aquifer occur along the Delaware River in southeastern Bucks County where the sands and gravels near the base of the Pleistocene section are fairly well sorted.

The reported yields of 61 wells tapping the Pleistocene deposits in the Coastal Plain area have an almost meaningless range of from 8 gpm to 7,000 gpm. The specific capacities of 30 wells for which test data are available have a correspondingly wide range of from 2 gpm per foot of drawdown to 65 gpm per foot of drawdown and the average is 21 gpm per foot of drawdown. The highest specific capacities are recorded for wells that are located adjacent to surface sources of recharge. This indicates the relative importance of induced recharge to the sustained yield of the aquifer.

A pumping test was made on wells tapping the Pleistocene deposits in south Philadelphia, and the results of this test are summarized in Table 8. The field coefficients of transmissibility are generally lower than those determined for the Farrington sand member (Table 6). Table 8 shows that the storage coefficients determined at the various observation wells are definitely in the artesian range, indicating that locally the Pleistocene deposits contain water under artesian conditions. Such artesian conditions occur where the deposits are overlain by sediments of recent age which — being much less permeable than the Pleistocene sediments — act as a confining bed for the Pleistocene aquifer.

Table 8.—*Results of pumping test to determine hydraulic properties of the Pleistocene deposits.*

Date Dec. 13-14, 1949	Pumped well Ph-412	Observation well	Discharge (gpm)	Transmissibility (gallons per day per foot)	Storage Coefficient
		Ph-409	430	60,000	.0006
		Ph-411		45,000	.0006
		Ph-412		36,000	.00000
		Ph-413		37,000	.0006
		Ph-414		36,000	.0005
		Ph-415		40,000	.0007
		Ph-416		36,000	.0006

Recent Deposits

Recent deposits consisting of richly organic, dark gray mud, silt, and fine sand underlie the channels and tidal flats of the Delaware River and its principal tributaries. These sediments are most abundant in south Philadelphia where the channels of the Delaware and Schuylkill River merge. In that locality wells have penetrated as much as 78 feet of Recent sediments. Elsewhere the Recent sediments are rarely more than 28 feet thick and usually are less than 10 feet thick.

The Recent sediments are unimportant as a source of ground water in the Coastal Plain area chiefly because they occur as a thin veneer of fine-grained material overlying other deposits that are much more permeable. The Recent sediments are generally much less permeable than the materials comprising the aquifers and constitute a leaky confining bed which tends to restrict the free interchange of water between the surface and ground-water bodies.

OCCURRENCE OF GROUND WATER

The physical properties of rocks, including their water-bearing properties, are fixed by nature and cannot readily be altered significantly by human activities. Some important aspects of the occurrence of ground water, such as recharge, discharge, movement, ground-water levels, and quality, however, do fluctuate naturally and are sensitive to artificial forces. Their response to various works of man may be critical in determining the utilization of ground water. Withdrawal of water from wells is the most obvious human activity affecting the occurrence of ground water, but land-use practices associated with urban development are also important, especially as they influence the quality of ground water. In this section of the report the natural occurence of ground water in the area is reconstructed as faithfully as possible, and the effects of various human activities in changing the natural conditions are discussed.

Hydrology of the Coastal Plain

In the Coastal Plain of Pennsylvania the largest supplies of ground water occur in the unconsolidated and weakly consolidated deposits of Cretaceous and Pleistocene age. The underlying crystalline rocks are relatively unimportant as sources of ground water except along a narrow belt adjacent to the Fall Line where the unconsolidated deposits are thin or absent.

The unconsolidated-rock aquifers of the Coastal Plain of southeastern Pennsylvania occur in two distinct but locally interconnected natural hydraulic systems — one typically artesian and the other essentially water-table. The artesian system comprises areally extensive confined aquifers characterized by distinct hydraulic and hydrologic properties and by hydraulic continuity with relatively remote sources of recharge . The water-table system comprises unconfined and semiartesian aquifers having common hydraulic head, similar hydrologic properties, and local sources of recharge.

The crystalline rocks, which underlie the Coastal Plain sediments and border them on the west, serve chiefly as a lower confining layer to retard movement of water out of the overlying aquifers. Ground water occurs under water-table conditions in the outcrop area of the crystalline rocks near the Fall Line. In the subsurface of the Coastal Plain the crystalline rocks inherit the hydraulic head of the overlying unconsolidated-rock aquifer.

Water-table System

For the purposes of this report the water-table system is arbitrarily assumed to include all aquifers which are recharged directly from local precipitation and other surface sources. It comprises most of the superficial deposits of Pleistocene and Recent ages and the underlying Old Bridge sand member of the Raritan formation. The water-table system also includes the Sayreville and Farrington sand members of the Raritan formation, where the lower and middle clay members are absent in a few localities near the Fall Line. Water-table conditions occur in the outcrop areas of the water-bearing beds of Pleistocene age, but artesian conditions do occur in the Pleistocene aquifers where they are overlain by alluvial silt and clay of Recent age and in the Old Bridge member where the overlying upper clay member has not been removed by erosion.

Artesian System

The artesian system extends from a high-level recharge area east of Trenton, N. J., southward and westward beneath southern New Jersey to low-level discharge areas in the valley of the Delaware River. It is represented in Pennsylvania by the Farrington and Sayreville members of the Raritan formation and by the overlying lower and middle clay members. The physical continuity of the artesian system in

Pennsylvania is interrupted in many places between the Benjamin Franklin Bridge at Philadelphia and the Bucks County line, where the Delaware River encroaches upon the Fall Line, but the hydraulic continuity of the artesian system is preserved by the continuation of the beds beneath adjacent areas of the Coastal Plain in New Jersey.

The approximate extent of the artesian system in Pennsylvania is shown in Plate 19, which was prepared from the isopachous maps in Plates 7, 14, 17, and 18. In south Philadelphia the artesian system consists principally of the Farrington member, and in southeast Bucks County it consists principally of the Sayreville member. The shaded parts of Plate 19 denote areas where the confining beds are absent and the artesian aquifers merge with the regional water-table aquifers. Where this occurs water is free to move between the two hydrologic systems according to local head differentials.

The Probable Natural Ground-water Regimen

Before being developed by man, the natural hydrologic systems were in a state of dynamic equilibrium — that is, over a seasonal cycle or a complete climatic cycle, recharge equaled discharge, and the balance between them was maintained by the natural hydraulic gradient which regulated the rate and direction of ground-water movement.

Recharge

Under natural conditions the chief source of recharge to the Coastal Plain sediments was precipitation over the outcrop areas of the water-bearing beds. The intake area for the regional water table comprised the local areas of outcrop of the water-table aquifer in southeastern Pennsylvania. The artesian system was recharged chiefly in a high-level intake area east of Trenton, N. J., where the Farrington and Sayreville members are hydraulically continuous with the overlying superficial deposits of Pleistocene age.

The natural water table in the intake area was close to land surface through much of the year because the land gradients were low in the recharge area and precipitation was abundant and evenly distributed throughout the year. The natural rate of recharge was controlled primarily by the capacity of the aquifers to transmit water laterally away from the intake areas; and because the available recharge was more than the aquifer could transmit under existing hydraulic gradients, most of the recharge was rejected.

The water-table unit was recharged from below also by the upward movement of water through and around the confining clay bed of the subjacent artesian system. This is not ground-water recharge in the true sense of the term because it does not represent water entering ground-water storage from another phase of the hydrologic cycle. However, the process of inter-aquifer movement of ground water in response to differential hydraulic head does account for considerable recharge to individual aquifers, and, as described in another section, it is an especially important source of recharge to aquifers under development.

Movement

Before the development of ground-water supplies in the Coastal Plain, the configuration and slope of the water table were largely controlled by the surface topography. Local details of movement were highly complex owing to the inhomogeneity of the water-table aquifer and the irregularity of the topography, but the general pattern of ground-water movement in the regional water-table body was from the highest points on the Coastal Plain topography, near the Fall Line, toward the Delaware and Schuylkill Rivers. The natural hydraulic gradient was slight, on the order of 10 feet to the mile or less, and the rate of movement was correspondingly low.

The pattern of ground-water movement in the artesian system under natural conditions was more uniform than in the water-table system because the hydraulic gradient of the artesian system was not so immediately responsive to anomalies in the surface topography. The regional pattern of movement prior to development is shown in Figure 6, which is based on the assumption that the piezometric head in the artesian system declined from an altitude of 70 feet above mean sea level in the intake areas to mean sea level in the discharge areas bordering the Delaware River. A complete description of the flow diagram and the assumption upon which it is based is given by Barksdale and others (1958).

The local details of natural movement of ground water in the artesian system in southeastern Pennsylvania were complex and cannot be reconstructed quantitatively from available data. But the significant features of movement in the Farrington member in south Philadelphia can be deciphered on a qualitative basis from knowledge of the geologic controls and miscellaneous reported water levels in

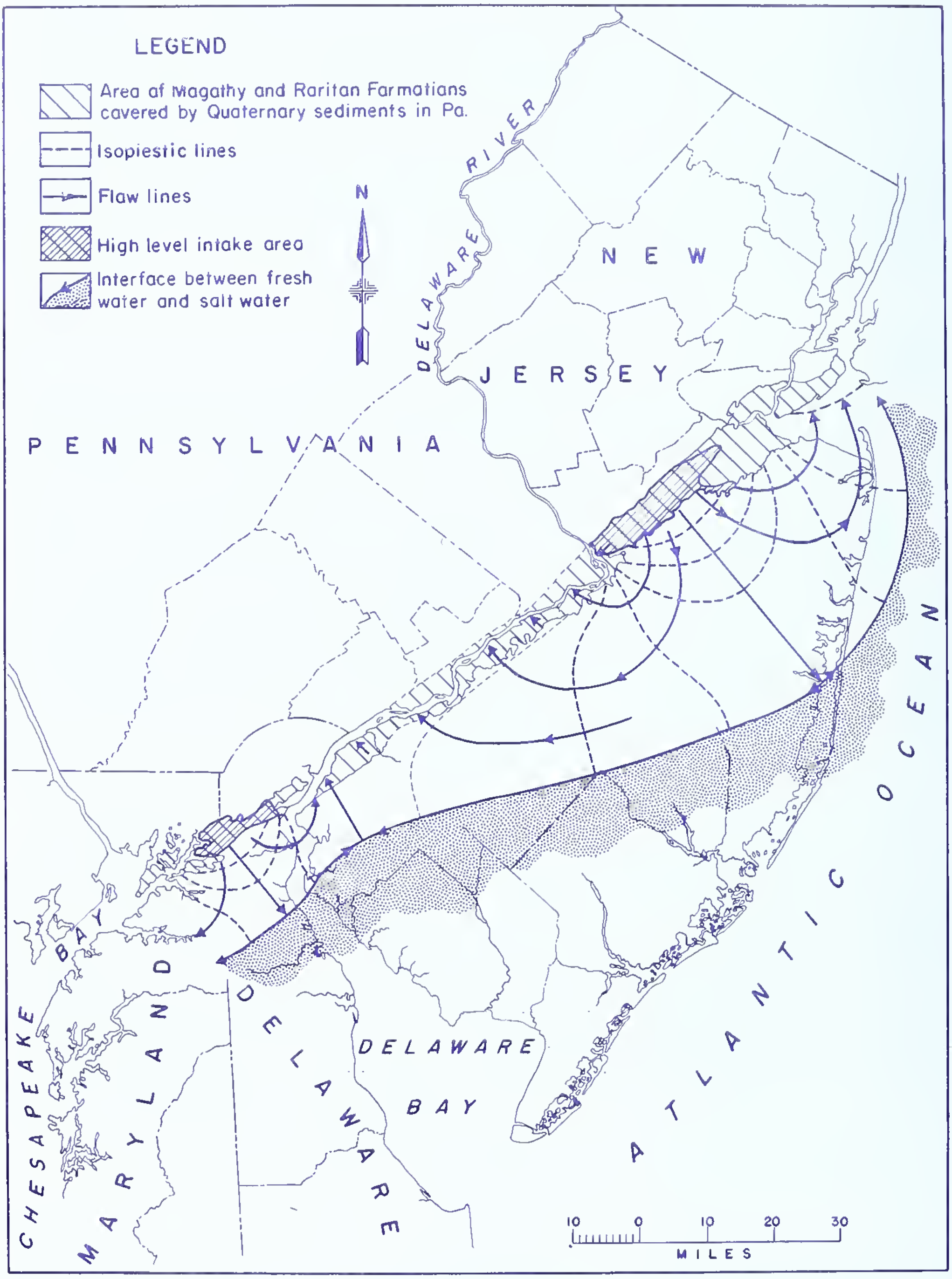


Figure 6.
Map showing the theoretical flow pattern in the Raritan formation prior to development. After Barksdale (1958, p. 110).

wells that were drilled in the early years of development. These data were used to construct the piezometric map in Figure 7, and the cross sections shown in Plate 20. The cross section (Pl. 20) illustrate the approximate conditions of movement in the Farrington member and in the water-table aquifer in the south Philadelphia area. Equivalent data on natural conditions are not available for the Sayreville member in south Philadelphia or for either the Sayreville or Farrington members in southeastern Bucks County, but presumably similar conditions prevailed in the artesian system throughout the area.

The piezometric map (Fig. 7) shows the general direction of movement in the artesian system prior to development. This movement was northwestward, or updip, toward points of natural discharge where the artesian head was higher than that of the water table. This pattern of movement was modified by local recharge to the Farrington member in other areas where the water table was higher than the artesian head. The extent of the updip migration of water under the influence of the regional artesian head differed from place to place, according to the continuity of the confining clays and the differential head relationships in the areas where the aquifers merge.

The local pattern of movement in a given area varied with time. The conditions shown in Plate 20 represent the long-term "average" natural hydrologic environment, which was a composite of the variations in conditions that occurred in response to relatively short-term seasonal and secular climatic cycles. Thus, during prolonged dry periods the water table may have been lower than the artesian head over a large area, thereby promoting discharge of the artesian aquifer in those areas that were normally sources of local recharge. Conversely, during exceptionally wet periods the temporary position of the water table may have been higher than the artesian head throughout much of the area, thereby promoting local recharge to the artesian system in many areas..

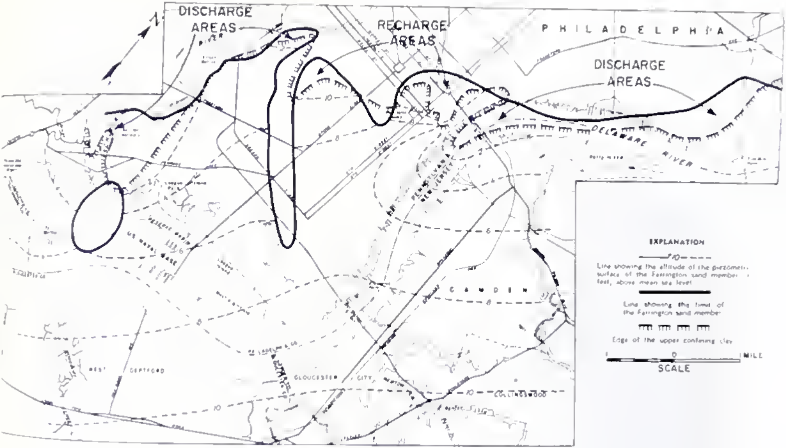
Although the interpretation of the original general pattern of movement is based on inferences from meager hydraulic data, it is supported by quality of water data, described in the subsection "Quality of the native water." These show that the chemical character of the native water in the Farrington member beneath south Philadelphia and Camden is unique in that area but closely resembles the chemical character of water in the aquifer to the south and east in New Jersey.

The rate of movement in the artesian system before it was disturbed by man-made influences differed from place to place largely according to local conditions of recharge and discharge which, in turn, determined the local hydraulic gradients. The steepest gradients occurred in the areas of recharge and in the areas of discharge — where the confining clays were least effective, and where considerable loss of head occurred because of movement of water into overlying beds. Thus, the natural gradient of about 2 feet per mile in the intake area declined to about ½ foot per mile in the central part of the New Jersey Coastal Plain. (See Barksdale and others, 1958, Fig. 19.) In south Philadelphia the natural gradient was approximately 2½ feet per mile — assuming that the artesian head declined from about 10 feet above mean sea level near the Delaware River to mean sea level in the vicinity of the Vare Avenue Bridge, where the head of the League Island trough intersects the channel of the Schuylkill River.

Discharge

As the hydraulic gradients of both the water table and the artesian system sloped toward the valley of the Delaware River, the common endpoint of subsurface drainage in both systems was the Delaware River or one of its tributaries. The water-table aquifer discharged directly into the stream, but discharge from the artesian system generally followed a more devious path — moving through or around the confining clay into the water-table aquifer and thence to the stream.

Seepage to surface-water bodies accounted for a substantial part of the natural discharge from the artesian system in southeastern Pennsylvania but only a part of the natural discharge from the water table. As the water table in the Coastal Plain commonly lay within a few feet of land surface, considerable natural discharge occurred by evaporation from the contiguous soil zone and by transpiration from plants whose roots penetrated to the water table. Unlike discharge to streams, losses to evapo-transpiration were distributed throughout the areal extent of the water-table unit. They were greatest in low-lying areas such as marshes, where the water table was at or very near land surface. Discharge from the water table into the atmosphere was greatest in summer and early fall, during the period of maximum plant growth and highest air temperature; it declined sharply to a negligible quantity during winter and early spring.



Base from Geological Survey quadrangle topographic maps

Figure 7

Map of the Philadelphia area showing a hypothetical representation of the piezometric surface of the Farrington sand member of the Raritan formation before pumping began

Natural discharge to streams occurred throughout the year, but the rate varied seasonally according to the position of the water table with respect to the stage of the river or stream. This type of discharge from the water-table unit was usually greatest in spring when the water table was highest, following the period of minimum loss to evapo-transpiration. Conversely, natural discharge from the artesian system was greatest in late summer and early fall when the water table was lowest and offered the least opposition to movement from the artesian system.

Fluctuations of Water Levels

Ground-water levels may show diurnal, seasonal, and secular cycles of fluctuation which reflect consistent repeated occurrences in the hydrologic environment; they may also show random fluctuations caused by irregular incidents in the environment, such as storms and the passage of heavy vehicles. The character and magnitude of the fluctuations are functions of the climate and the mode of occurrence of the ground water. Thus, they do not have a single cause or effect, and the various fluctuations are superimposed one upon another so that knowledge of the history of each is necessary in order to interpret the composite hydrograph.

The water table in the Coastal Plain sediments fluctuated in response to variations in recharge and discharge which, in turn, were related chiefly to rates of evapo-transpiration. The most obvious characteristic in the natural pattern of fluctuation of the water table was the seasonal cycle. The water table was usually highest in spring, after the period of maximum recharge and minimum loss of water by evapo-transpiration. It was usually lowest in fall, after a protracted period of high evapo-transpiration resulting in virtually no recharge, and continued or accelerated natural discharge.

Near the Delaware River seasonal fluctuations of the water table were not so pronounced because the river, which is a tidewater body with a relatively constant mean stage, functioned as a balancing reservoir. It subdued the cyclic trends by accepting ground-water discharge when the water table was high, and provided ground-water recharge when the water table was low. Close to the river, however, the water table showed semidiurnal fluctuations in response to the 6-foot tidal

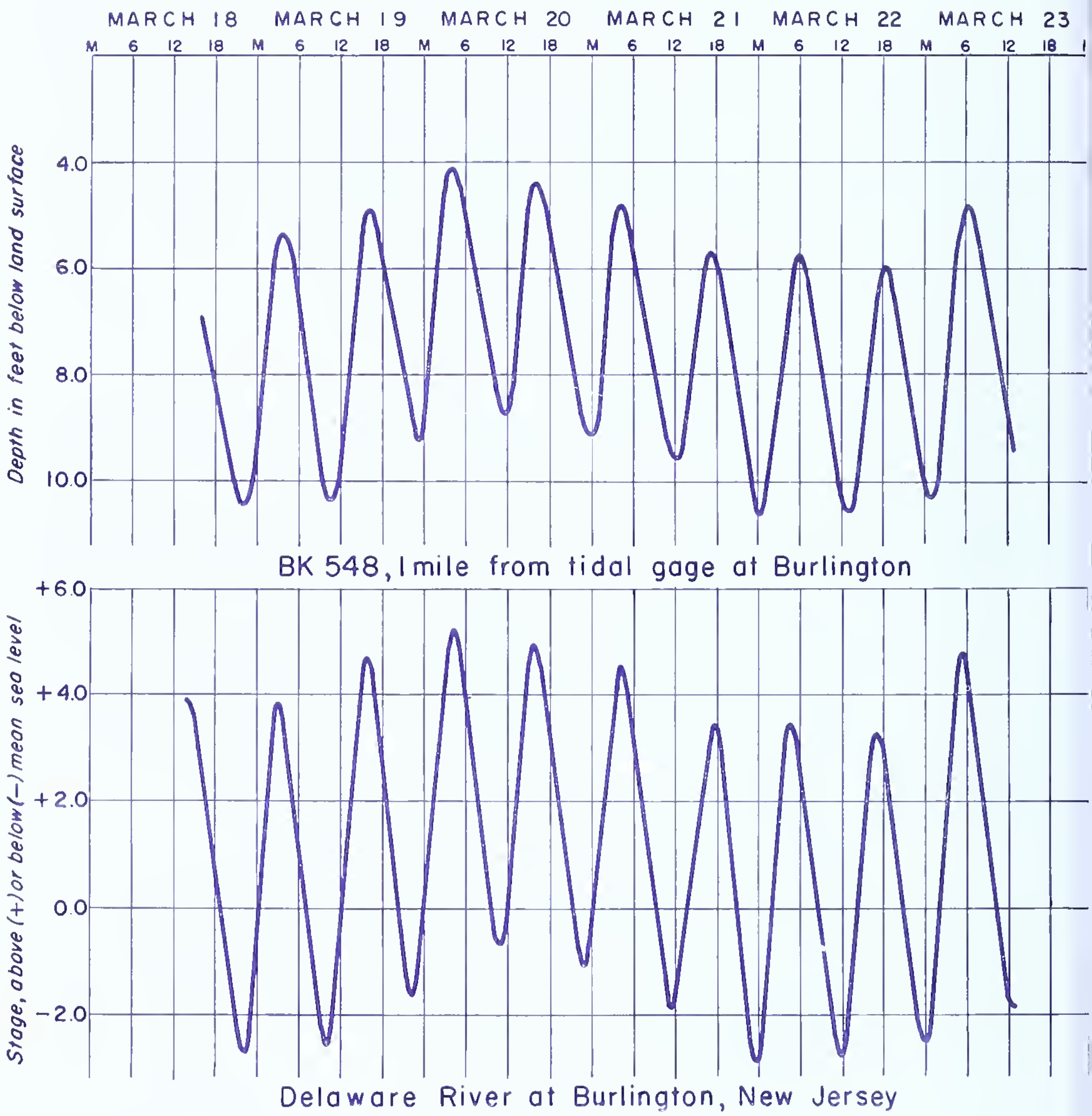


Figure 8.
Hydrographs comparing the tidal fluctuations of the Delaware River with diurnal water-level fluctuations in well Bk-548 at Bristol, Bucks County, Pa.

impulse of the Delaware River (Fig. 8). These fluctuations, caused by local changes in head, were not transmitted more than a few hundred feet from the river's edge.

Natural, random fluctuations of the water table occurred chiefly as the result of local rainfall of above average intensity or duration. These effects commonly persisted for only a few hours or days.

Natural fluctuations of artesian pressure were slight compared to those of the water table. Near the subsurface recharge area of the artesian aquifer the artesian pressure showed a subdued response to fluctuations of the water table. But downdip, beyond the influence of local recharge, the most conspicuous fluctuations in artesian pressure were semidiurnal tidal cycles caused by changes in the loading effect of tidal water in the Delaware River. Plate 6 shows the relation between changes in river stage and the fluctuations of water levels in wells.

The tidal impulse is transmitted through the aquifers to the wells as a simple harmonic wave. In transit through the aquifer the typical sinusoidal wave form characteristic of tidal fluctuations in preserved. However, as the wave moves through the aquifer the amplitude of the wave decreases until, at some distance from the river bank (usually 1 mile or more in an artesian aquifer), the fluctuations diminish to the point where the tidal impulse can no longer be recognized.

In unconfined, or water-table, aquifers the tidal impulse is produced by an exchange of water between the river and the aquifer immediately adjacent to it. The changes in ground-water storage are reflected by alternate rising and falling of the water table in the aquifer immediately adjacent to the river. Because the rate of movement of ground water is extremely slow the volume of water that enters of leaves the aquifer during a single tidal phase is small, and the volume of the aquifer influenced by the short-term changes in storage is correspondingly small. The tidal impulse is therefore, not transmitted more than a few hundred feet from the riverbank. The upward movement of water level in a well, which is the result of the tidal impulse, is induced by the change in water-table gradient caused by the change in river stage during high tide.

In artesian aquifers the tidal impulse is produced by changes in hydraulic pressure. If the aquifer is hydraulically connected to the river through a subaqueous outcrop, changes in river stage produce changes in hydraulic head in the aquifer. Although some water may enter and leave the aquifer during successive tidal phases, the slight change in storage is incidental to the changes in hydraulic pressure created by rising and falling tides. Even if the aquifer is insulated from the river by the presence of a continuous upper confining layer, the loading effect of changes in river stage are transmitted through the confining layer to the aquifer. The resulting expansion and compression of the aquifer skeleton sets in motion a wave of hydraulic pressure.

During the course of this investigation a study was made to determine the effect of river tides on water levels and artesian pressures at various distances from the river. Continuous water-level recorders were installed on a number of observation wells adjacent to the river and the fluctuations of water level were compared with the tidal fluctuations of the Delaware River determined from stilling wells placed in the river opposite the observation wells. From these data it was possible to compute the ratio between the amplitude of water-level fluctuations observed in wells, and the amplitude of corresponding tidal fluctuations in the river. (See Table 9.) For some wells it was also possible to compute the lag in time between the arrival of high or low tides in the river and maximum or minimum water levels in wells. (See Table 9.)

Table 9.—*Summary of the effect of river tides on the fluctuations of water levels in wells.*

Well no.	Distance from shoreline (feet)	Type of aquifer	Average water level fluctuations / Average Tidal fluctuations	Time lag (hours)
Bk-500	30	Water-table	0.094	0.62
Bk-548	120	Artesian	.770	.65
Bk-628	1,700	do.	.023	......
Bk-647	120	Water-table	.033	......
Bk-671	300	do.	.026	......
Bk-672	200	do.	.036	2.79
Ph-13	1,200	Artesian	.039	......
Ph-19	150	do.	.310	......
Ph-20	400	do.	.320	......
Ph-30	4,400	do.	.005	......
Ph-77	1,100	do.	.032	......
Ph-143	1,700	do.	.129	......
Ph-190	3,000	do.	.009	2.35
Ph-242	1,400	do.	.220	......
Ph-249	1,500	do.	.196	......
Ph-374	350	do.	.383	.47

The natural water table and artesian pressure head fluctuated through long-term cycles also, during which the average ground-water levels showed rising or declining trends in response to climatic cycles of several years duration. Long-term cycles are the most difficult to detect because many years of records of water levels and climatological data are required to identify climatic cycles and evaluate their effect on ground-water levels. Such data are not available for southeastern Pennsylvania.

Presumed Original Quality of Ground Water

Water-table Aquifer

Analytical data collected during the period 1945 to 1958 for water from wells that tap the shallow water-table aquifer are given in Table 12. All the supplies these samples represent are believed to have been contaminated to some extent by human activities. Thus, original analyses cannot be cited as exemplifying natural conditions. But a reasonable estimate of the gross chemical character of the native water can be synthesized by interpreting some of these data according to the presumed conditions in the natural environment and known conditions in analogous areas where the virgin environment has not been so severly modified.

It has been previously shown that under natural conditions the hydrologic history of the unconfined ground water was dominated by local events. The only external factor in the natural regimen was interformational leakage from the underlying confined aquifers and basement rocks, but recharge from these sources was negligible compared to that supplied by participation and probably had little effect on the quality of water. As precipitation contains very little material in solution when it reaches the land surface, it follows that the chemical character of the native ground water was essentially controlled by the local hydrologic environment. Furthermore, as the environment was monotonously similar throughout the area, it follows also that the chemical character of the native ground water did not exhibit sharp contrasts from one place to another.

The chemical characteristics of the native ground water were largely acquired from the materials with which the recharge water came in contact in the unsaturated zone of rock above the water table.

Water in the unsaturated zone was slightly acidic owing to the solution of organic acids from the soil zone and carbon dioxide from the atmosphere and soil. For example, carbon dioxide reacts with water to form weakly dissociated carbonic acid. The acid in turn reacts with minerals in the soil, and soluble products of these reactions are taken into solution. The principal ions involved are calcium and (to a lesser extent) magnesium of the cations and bicarbonate of the anions. In some waters sulfate may be a strong secondary anion. Sodium and chloride derived from airborne salts are minor

constituents in the recharge water, and nitrate which is an end product of natural degradation of some organic materials, is present in trace quantities. Thus, when the ground-water recharge reaches the water table it is typically a weekly acidic, slightly mineralized, calcium bicarbonate or calcium sulfate water.

Below the water table, solution is not an important factor in changing the character of the ground water in the unconfined aquifers. Most of the soluble materials that may have been present in the sediments were leached by circulating ground water in the geologic past, and ground water in recent years was essentially in equilibrium with its geologic environment.

The chemical character of the ground water may have changed somewhat owing to reactions such as reduction of sulfates by hydrocarbons and the escape of the sulfur as hydrogen sulfide gas. But these reactions did not affect the total concentration of dissolved constituents which presumably remained relatively constant while the ground water was in transient storage in the unconfined aquifers.

The characteristics of the quality of the native water are suggested by analytical data for well Bk-535 which are given in Table 12. A sample collected in August 1943, before the well was placed in service, contained 3 ppm of chloride and 0.5 ppm of nitrate. A sample collected 7 years later contained 8 ppm of chloride and 8.6 ppm of nitrate but only 7 ppm of bicarbonate and 5.8 ppm of sulfate. The cations were not reported individually, but the combined concentrations of sodium and potassium was 5.5 ppm, and that of calcium and magnesium was 7.2 ppm calculated as calcium. The increased concentrations of chloride and nitrate and an equivalent amount of the cations are due probably to a source of induced recharge. Based upon a study of earlier analyses the following hypothetical analysis of native water is proposed as a basis for comparison with later analyses.

	Ca+Mg	Na+K	HCO_3	SO_4	Cl	NO_3
ppm	5	2	7	5.8	3.0	0.5
epm	0.250 (as Ca)	0.086 (as Na)	0.115	.121	.084	.008

This analysis agrees with data from similar areas in New Jersey, where contamination has not taken place (Barksdale, 1958, p. 62, sample no. 18), and is believed to be representative of the quality of the native ground water in the unconfined aquifers, but of course it does not illustrate all variations. The natural environment was relatively uniform, variations must have been slight and must have affected chiefly the relative concentrations of individual constituents, especially those of bicarbonate and sulfate.

Artesian Aquifer

In the intake area of the artesian aquifers, in central New Jersey, conditions were essentially the same as described for the unconfined aquifers in southeastern Pennsylvania. The recharge water was slightly mineralized, soft, calcium-bicarbonate or sulfate water having a pH of 6 or less.

In its slow movement through the artesian system toward areas of discharge the ground water was physically and hydraulically insulated from external contamination, but its mineral content increased and its corrosiveness diminished as a result of chemical reaction with mineral matter indigenous to the aquifers. The accretion of dissolved constituents involved chiefly bicarbonate, of the anion group, and calcium, of the cation group. But in the downdip reaches of the aquifers the composition of the water was further modified by base exchange, whereby alkaline earths were replaced by sodium as the principal cation where there was a significant increase in chloride. The exchange media probably consisted of glauconitic sands in marine facies of the Raritan formation which also contributed chloride to solution. Thus, the mineral content and character of the ground water differed from place to place, more or less in proportion to the distance from the intake area. The water moved along arcuate flowlines corresponding to the theoretical flow pattern shown in Figure 6.

Within the Pennsylvania Coastal Plain area, southeastern Bucks County is the shortest flowline distance from the intake area, and there the native artesian water contained the least concentration of dissolved solids. The natural-quality characteristics are suggested by the analytical data for well Bk-634 (Table 12) which is screened in the Sayreville sand member. The earliest sample was collected in September 1946, about 2 years after the well was drilled. It contained

68 ppm of dissolved solids, including the alkaline earths calcium and magnesium as the principal cations and bicarbonate as the principal anion. Contamination was evident from the concentration of 12 ppm of nitrate, most of which must have been derived from a local source in response to pumping. The remaining anions are believed to be reasonably representative of natural conditions. The concentration of cations in the natural water, therefore, was probably slightly less than that reported for the 1946 analysis but the exact concentrations are unknown.

Equivalent data are not available for the Farrington sand member in Bucks County, but the chemical character of the native water is indicated by analytical data for well Bk-629 (Table 12). A sample collected in March 1948 before the well was placed in service, contained 6.0 ppm of chloride, 0.5 ppm of nitrate, 58 ppm of total hardness as calcium carbonate, 105 ppm of dissolved solids, and a pH of 6.0. This differs from the native water in the overlying Sayreville member chiefly in the content of dissolved solids which is higher in the Farrington sand member because its confining bed, the lower clay member, is a more persistent and effective aquiclude than the middle fire clay member which overlies the Sayreville member. As a result, ground-water circulation in the Farrington member was inhibited, which condition favored solution of mineral matter. But judging from the ratios of hardness to dissolved solids, the relative concentrations of the principal constituents in the water from the two members were about the same.

Southwestward, or downstream, from Bucks County the flowline distance increases between the intake area and points of discharge in the valley. (See Fig. 6.) The artesian aquifers do not extend into Pennsylvania beneath the reach of the Delaware River between southeast Bucks County and south Philadelphia, but analytical data from adjacent areas in New Jersey (not presented here) show a gradual increase southwestward in the dissolved-solids content of the ground water. South Philadelphia is most distant from the intake area, and there the quality of the native ground water in the Farrington member is well documented by analytical data from the Naval Base well field. The earliest analyses of water from wells Ph-1, 3, 4 and 7 that are given in Table 12 are most representative of natural conditions because these wells were most effectively insulated from local contamination at the time the samples were collected. These

data show that the concentration and character of the water were remarkably uniform in the area. Dissolved solids ranged from 121 ppm to 133 ppm, and each of the samples was a chemically neutral sodium bicarbonate-type water having a significant concentration of chloride as a secondary anion. These characteristics stem from the downdip migration of the circulating ground water along the flowline (Fig. 6) into the reach of the aquifer where marine facies base-exchange processes are active. Any of the samples cited above might be considered typical of the native water in the Farrington member in south Philadelphia.

The quality of the native water in the Sayreville member in south Philadelphia probably was indistinguishable from that of the Farrington member. This is suggested by the fact that by 1954 the water from the Farrington had changed to an alkaline earth-bicarbonate type that was moderately high in iron. Water of similar quality was obtained from the Sayreville member in 1954, as shown by analyses of water from Ph-10 which taps the Sayreville at the Naval Base (Table 12). Analyses of samples collected from this well between 1951 and 1954 show an increase in the alkaline earth content of the water and a moderate increase in dissolved solids. As withdrawals from the Sayreville member at the Naval Base commenced in 1944, and withdrawals from the Farrington member commenced in 1941, it is reasonable to suppose that this transition in chemical character began prior to 1951, and that the Sayreville had a native water of about the same chemical character and concentration as the Farrington member.

EFFECT OF HUMAN ACTIVITIES ON THE OCCURRENCE OF GROUND WATER IN PHILADELPHIA COUNTY

South Philadelphia is an area of intense urban development. During the various stages of urbanization, human activities have had an ever-increasing effect on the ground water in the area. These activities include withdrawals from wells and various miscellaneous activities that are related chiefly to occupancy of land but which have had significant incidental effects on the hydrologic environment.

Changes in the Region

Incidental Effects of Urban Development and Related Land-use Practices

Urban development involves a number of human activities that are not directly concerned with development of water supplies but which may influence considerably the local occurrence and quality of ground water. In the most intensely developed urban areas, such as the Philadelphia commercial and industrial districts, recharge to the water table is diverted by buildings and pavements which form an impervious covering over the land surface. These same structures also insulate the water-table aquifer from discharge by evaporation and plant transpiration. Similarly, storm and sanitary sewers and drainage ground-water drainage devices when the water table is above grade. of recharge when the water table is below drainage grade or as ground-water drainage devices when the water-table is above grade. Leakage from City of Philadelphia water mains probably supplies considerable recharge to the water table. Graham and Kammerer (1952, p. 37) point out that leaks in the distribution system are common occurrences, and, though most of them quickly become evident and are repaired, many small leaks and probably some large leaks remain undetected. Other sources of artificial recharge are disposal wells and tile fields through which liquid industrial wastes are discharged underground.

Urban land-use practices may also influence the local hydrology in other ways. Much of south Philadelphia is built upon tidal flats that were reclaimed by landfill projects, and part of the Navy Base was developed by filling a natural channel of the Delaware River that formerly separated League Island from the west bank. As a result,

the land surface was elevated, and these low-lying or submerged areas of natural ground-water discharge were converted to areas of recharge or transient storage.

These human activities undoubtedly have had some effect upon the annual rates of ground-water recharge and discharge and the average quantity of ground water in storage but these cannot be evaluated quantitatively. By the virtual elimination of evapo-transpiration as a factor of discharge, seasonal fluctuations in the rates of recharge and discharge and in the amount of ground water in storage have been diminished, and the altitude of the water table, where unaffected by pumping, is probably nearly static.

Local Effects of Withdrawals from the Water-table Aquifer

The withdrawal of substantial amounts of ground water from the water-table aquifer did not begin until about 1900, when a few industries in central Philadelphia were successful in obtaining adequate supplies of water from shallow wells. As the success of these early wells became known, other industries in the area drilled similar wells. By 1920 approximately 200 shallow industrial wells had been drilled, mainly in the industrial districts of central and northeast Philadelphia. The estimated total pumpage from these wells was less than 2 million gallons per day.

In the ensuing 20-year period (1920-40) the number of wells tapping the water-table unit was approximately doubled, and as a result of improvements in well-construction techniques, the volume of withdrawals is estimated to have increased to about 10 million gallons per day. The principal areas of new developments were along the east bank of the Schuylkill River and along the Delaware River upstream from the Benjamin Franklin Bridge at Philadelphia.

Since 1940 the development of new supplies from the water-table aquifer has been drastically curtailed owing to the severe contamination of the aquifer. During World War II, however, several wells were drilled and screened in the water-table aquifer at Greenwich Point, in south Philadelphia. Since then few wells have been drilled to develop supplies from the water-table unit except at sites immediately adjacent to the rivers, where recharge of water of acceptable quality could be readily induced.

Prior to the development of water supplies from the shallow Coastal Plain sediments in the Philadelphia area, the water table was considerably above drainage level and had a fairly uniform slope toward the Schuylkill and Delaware Rivers. After pumping began, however, water levels in the vicinity of discharging wells were depressed in response to the removal of water from storage. The cones of depression around the pumping wells eventually reached areas of rejected recharge or natural discharge, and the water-level drawdown was lessened by an adjustment in the regimen. Pumping from wells immediately adjacent to the Schuylkill and Delaware Rivers reversed the natural gradient in those areas and induced river recharge. The effects of river recharge diminished with increased distance of the wells from the riverbank, however, and wells remote from the river were dependent upon other sources of recharge.

Contamination of the Water-table Aquifer

Human activities have had a significant and, invariably, a deleterious effect upon the quality of the unconfined ground water in Philadelphia. Essentially all recharge to the water table is subject to direct or indirect contamination from some human activity. Direct contamination results from the disposal of liquid wastes into the aquifer through means such as leaky sewers, wells, and cesspools. In most instances these sources operate intermittently. Both the volume and the character of the contaminated recharge from a given direct source may vary greatly—especially where industrial wastes are involved—and much contamination probably results from random incidents such as the accidental spilling of an industrial chemical. Indirect contamination occurs where recharge waters move through dumps and landfills, dissolving the most soluble constituents of the refuse and transporting them to the water table. Contamination from these sources occurs continuously. The character of the contaminant differs from place to place according to the local nature of the landfill, but it is relatively constant with time at any given point. Another form of indirect contamination occurs as the result of chemical reactions in the unwatered volume of the water-table aquifer around a pumped well. In the Philadelphia area, however, this contamination is masked by the much more severe contamination from other sources and is not discussed here.

Contamination presents an especially insidious threat to the utility of ground-water supplies. Because of the low velocity of ground-

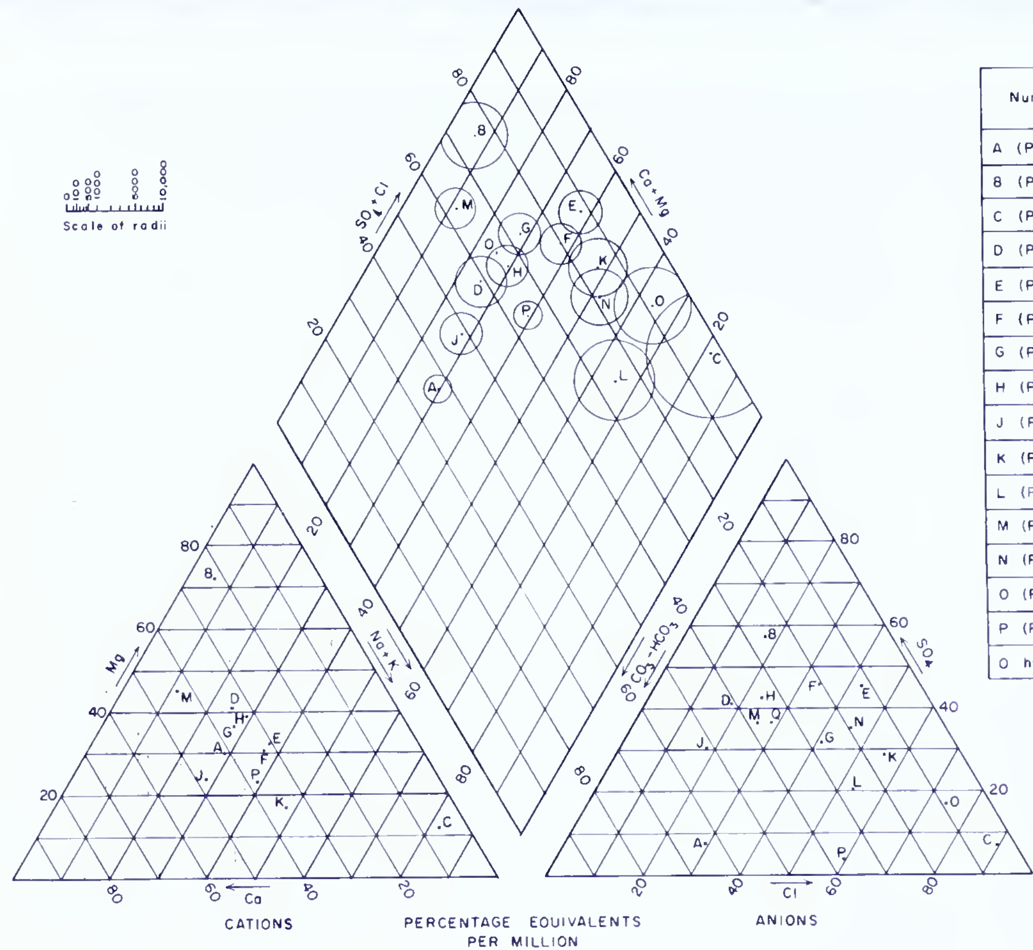
water flow, a given source may contribute recharge for many years and contaminate a considerable segment of the aquifer before the condition becomes evident. When such contamination is discovered, little can be done to alleviate the condition. Locating the source of contamination and insulating the aquifer from it is not generally feasible, and it is almost impossible if an indirect source is involved. Furthermore, as ground-water movement is laminar, there is virtually no vertical or lateral physical dispersion of the contaminated water such as occurs in streams where the flow is turbulent. Chemical diffusion occurs at the boundaries of the contaminated body, but the rate of ionic dispersion is extremely slight — less even than the rate of movement of the ground water. Thus, there is little mixing or dilution of waters in the zone of saturation, and the contaminated water tends to remain a discrete body throughout its ground-water experience.

The problem of contamination is complicated by the effects of pumping, whereby the gently sloping natural water table is marked by overlapping and continuously changing cones of depression. These cones serve to mix bodies of contaminated water within their reach, and may also induce recharge to wells from a relatively unpolluted source such as a nearby stream. In such an environment the quality-of-water relationships are complex and unpredictable. The character of the ground water may differ markedly from place to place owing to differences in the character of local recharge. Also, the quality of water yielded by a given well may change abruptly in response to changes in the character of recharge or the hydrodynamic environment.

Changes in Chemical Quality

The ubiquity of contamination is shown by comparing the presumed original quality of water with quality-of-water data for wells tapping unconfined aquifers in the Philadelphia area. All available pertinent chemical analyses of water are given in Table 12, and single-point trilinear plots of selected analyses and the presumed original water are shown in Figure 9. Comparison of these data with the estimated chemical characteristics of the native water previously described show that the quality of all of the supplies from which samples were obtained has depreciated.

The concentration of dissolved solids ranges from 135 to 4,270 ppm and the mean concentration is 679 ppm. Calcium and magnesium are the chief cations. Bicarbonate and sulfate are the chief anions in most samples, but nitrate and chloride are always present, and in some



EXPLANATION

Number	Date	Dissolved solids (ppm)
A (Ph-13)	2-24-51	194
B (Ph-45)	1-18-56	1150
C (Ph-98)	2-24-56	4270
D (Ph-108)	8-31-56	717
E (Ph-163)	2-23-56	476
F (Ph-175)	2-23-56	469
G (Ph-252)	1-20-56	455
H (Ph-281)	2-29-56	409
J (Ph-288)	2-10-56	451
K (Ph-304)	2- 3-54	958
L (Ph-306)	12- 2-49	1760
M (Ph-308)	2-10-56	439
N (Ph-311)	3- 3-54	850
O (Ph-389)	9-27-54	1550
P (Ph-411)	2- 9-56	182
O hypothetical	analysis of	native water

Figure 9.

Trilinear diagram showing the variation in the chemical character of unconfined ground water in the Philadelphia area.

samples they compose over half of the anion group. The concentration of iron ranges from 0.08 to 429 ppm and in most samples it is greater than 1 ppm.

The extraordinary range in the composition of the ground water from place to place is a reflection of the extreme differences in the character of the different sources of contamination. Similarly, the range in the composition of the water yielded by individual wells for which sequential analyses are available is a reflection of the effects of blending of recharge from multiple sources in response to pumping. Precise cause and effect relations cannot be determined, but the effects of the primary sources of contamination in specific areas are described below.

South Philadelphia

In the Naval Base and adjacent areas in south Philadelphia the quality of ground water in the unconfined aquifer is chiefly influenced by leachings from landfill used to reclaim the natural tidal flats.

Graham (1950) described conditions in the Naval Base area as follows:

> ***Much of the tideland and adjacent low areas of south Philadelphia are being filled in by city refuse. These same areas have received deposits of river silts laden with coal culm and organic material for many years. The superficial deposits in certain parts of southern and southwestern Philadelphia are so highly charged with organic material that the generation of methane and other gases is extensive. The Philadelphia Bureau of Health has reported that some of the "squatters" in south Philadelphia dump areas cook and heat with methane gas obtained by driving a pipe a few feet into the ground. Methane is generated freely in the bottom silts of the Schuylkill River, particularly during the warmer months of the year. Large blocks of loosely agglomerated river mud have been observed to rise from the bed of the river, buoyed up by the entrapped gases. Persistent bubbles of gas rising along the bulkheads and piers in the Naval Base area have been identified by Naval chemists as methane. In the summer of 1948, following the collapse of a large pier in south Philadelphia, a gas geyser erupted at the position of the fallen pier for approximately 18 hours, and at spasmodic intervals thereafter. This geyser is believed to have been caused by the release of gases from the loose river silts when they were compressed by the weight of the fallen pier.
>
> These river silts, together with the refuse of the dump areas, constitute a filter medium for much of the water recharged to the shallow gravels, and this appears to explain the poor quality of water in the shallow Pleistocene and Recent aquifers of south Philadelphia.***

There is no pumpage from the unconfined aquifers in the Naval Base area, but the quality of the landfill infiltrate is suggested by the analyses of water from wells Ph-13, 14, 15, and 16 (Table 12), which were drilled to supplement the Base supply but were not placed in service owing to the inferior quality of the water. The total dissolved solids of water from these wells ranged from 172 to 283 ppm, and the hardness ranged from 96 to 138 ppm. The water was a calcium bicarbonate type having chloride as the secondary anion. Sulfate was a minor constituent. Carbon dioxide was not reported for any of the samples, but it probably occurred in concentrations of 100 to 200 ppm or more. The most significant feature of the chemical quality of the water was the extraordinary concentration of iron which ranged from 170 to 429 ppm, probably as a result of high carbon dioxide content.

Somewhat similar conditions prevail in the well field of the Gulf Oil Refining Co. which borders the Schuylkill River just west of the Naval Base. The quality of the contaminated ground water in the unconfined aquifer in the well field of the Gulf Oil Refining Co. is shown by the analyses of water from wells Ph-43 and 44 (Table 12). These analyses show that the water is a moderately mineralized calcium bicarbonate type, but it differs from water in the Naval Base area in that sulfate is the secondary anion and the concentration of iron is much less. These differences probably are due to the dilution effects of induced infiltration from the Schuylkill River. This accords with the data below, for the water years 1945-46 to 1950-51, which show the Schuylkill River water to be of the calcium sulfate type with an average dissolved-solid content of about 215 ppm.

Average analyses of Schuylkill River water 1945-51

	Ppm	Percentage equivalents per million
Cations		
Sodium + potassium	10.3	14.3
Calcium	31.8	50.7
		35.0
Anions		
Bicarbonate	51.8	28.3
Sulfate	86.4	59.9
Chloride	9.0	8.5
Nitrate	6.3	3.3
Dissolved solids	215	

Especially severe contamination, chiefly from inorganic industrial wastes, occurs in widely separated areas in south Philadelphia. Such contamination is marked by a high concentration of dissolved solids which generally include a large concentration of one of the principal anions. When sequential analyses are available for a well, they commonly show extreme variations in quality.

The quality of water from well Ph-45 shows the effects of contamination from industrial wastes. The well is west of the Naval Base, in south Philadelphia, in a dumping ground which is a principal disposal site of chemical wastes for a number of chemical manufacturers. This area receives liquid wastes also from a drainage ditch that traverses the area and from disposal systems in local homes, none of which are served by sanitary sewers. When sampled in 1954 and 1956, well Ph-45 yielded a rather mineralized, extremely hard, magnesium sulfate water that contained from 56 to 173 ppm of nitrate but less than 1 ppm iron. The high concentration of magnesium reflects the character of the chemical wastes, and the more than three-fold increase in nitrate during the sampling period is probably related to local disposal practices.

The largest known area of contamination from industrial wastes lies at the head of the League Island trough, near Schuylkill River. (See Pl. 5.) Evidence of direct contamination in this area is contained in the analyses of water from wells Ph-60, 73, 76, 88, 90, and 98, given in Table 12. Data summarized in Table 10 show that between 1945 and 1956 dissolved solids ranged from about 600 to 4,300 ppm. In addition, the samples of water from these wells were found to have very high sulfate concentrations both in parts per million and in percentage anions, with the exception of the sample from well Ph-76 which had a high bicarbonate content and the samples from well Ph-98 which had a high chloride content. Although water from well Ph-98 had sulfate concentrations of 328 and 247 ppm in 1954 and 1956, an increase in contamination is shown by the increase in chloride concentration from 1,220 ppm in 1954 to 2,180 ppm in 1956. There was also considerable increase in dissolved solids, from 2,900 ppm in 1954 to 4,270 ppm in 1956.

Table 10.—*Dissolved solids of water from wells near the Schuylkill River.*

(Parts per million)

Well number	1945	1946	1947	1949	1953	1954	1956
Ph-60		790 a/			790 a/	854	
Ph-73	1,400				1,360		
Ph-76	600						
Ph-88		760 a/	740 a/				
Ph-90			1,040 a/				
Ph-98						2,900	4,270

a/ Based upon specific conductance.

Water from well Ph-73 showed the greatest change in chemical character. A sample collected in 1945 was a high sulfate water devoid of bicarbonate. The water had a pH of 3.6 which explains the absence of bicarbonate, as all carbonates are converted to carbonic acid in the presence of free mineral acids. In contrast, the sample collected in 1953 contained about equal concentrations of the principal anions, including bicarbonate; the concentration of sulfate was less than half that of the previous sample, but dissolved solids were virtually unchanged owing to the marked increase in bicarbonate.

During the years of record the concentration of iron has been variable in water from wells near the head of the League Island trough, and striking differences are recorded between maximum and minimum iron content. Water from wells Ph-88 and 90 contained less than 1 ppm and that from well Ph-98 contained less than 4 ppm of iron. Water from well Ph-76 showed the greatest concentration of iron recorded in the area—82 ppm in November 1945. The iron content of water from well Ph-60 varied from 34 ppm in January 1946 to 1.7 ppm in August 1953, and the iron content of water from well Ph-73 varied from 64 ppm in November 1945 to 2.8 ppm in August 1953.

The unusually high dissolved solids content and the extreme changes in the quality of the water from wells near the head of the League Island trough cannot be attributed to induced recharge from the Schuylkill River. The river would not provide water with an average dissolved-solids content much in excess of 200 ppm.

Leakage from sanitary sewers can also be discounted as a major source of contamination at the head of the League Island trough because the ground water contains higher concentrations of some inorganic constituents than occurs in raw sewage. According to Keighton (1954) the concentration of chloride in untreated sewage in Philadelphia is about 70 ppm which is much less than the concentration reported for the water from most of the wells near the head of the League Island trough. High nitrate content in ground water is usually an indication of leakage from sanitary disposal systems, but it occurs in significant concentrations only in wells Ph-88 and Ph-98.

The probable sources of contaminants near the head of the League Island trough are industrial wastes, but the mechanics of the contamination are not clearly understood. Disposal of inorganic wastes through wells, tilefields, or cesspools probably accounts for some of the contamination. Much contamination is obtained from chemical dumps and from accidental spillage of liquid chemicals. Regardless of the sources, the fact remains that contamination has greatly depreciated the value of ground water in the area.

North Philadelphia

Contamination of the unconfined aquifer is indicated also by analyses of water from wells Ph-304, 306, 311, and 389, in the Five Mile Point area near the Delaware River northwest of Petty Island. (See Pl. 1.) The first two wells mentioned end in crystalline rock, but under sustained pumping they must obtain most of their yields from the overlying unconsolidated-rock aquifer. Water from these wells has been highly mineralized in recent years, and the dissolved solids ranged from about 850 ppm in well Ph-311 to 1,760 ppm in well Ph-306. Chloride was the principal anion in all samples, and its relative concentration tended to increase with increased dissolved solids. Sulfate was the secondary anion, followed by bicarbonate, and nitrate was consistently a minor constituent. The alkaline earths and sodium were fairly evenly distributed in most samples; the former was dominant in the least mineralized samples, and sodium was dominant in the more highly mineralized samples.

The character of the waters from wells Ph-304, 306, 311, and 389 is reasonably uniform, as shown by the points K, L, N, and O plotted on the trilinear diagram in Figure 9.

As shown in Table 12 the concentration of iron in samples from wells in the Five Mile Point area ranged from 1.5 ppm in Ph-311 to 24 ppm in Ph-305.

Changes in the character of the water from a well are demonstrated by analyses of water from wells Ph-306 and 389. Ph-306 was sampled first in 1946 and yielded a slightly contaminated water containing less than 100 ppm of dissolved solids. It was sampled next in 1949, by which it was severely contaminated as the dissolved solids had increased to 1,760 ppm. Ph-389 was sampled in December 1953 and September 1954. Both samples showed the effects of contamination. In the period between samplings the chloride increased from 225 to 625 ppm and the conductance increased from 1,710 to 2,600 microhmos, indicating an approximately 50 percent increase in dissolved solids.

Marked differences in the quality of water between wells are obvious in these data and are more pronounced when data for well Ph-308 are compared to those of Ph-389 and Ph-311. Well Ph-308 is about midway between wells Ph-389 and Ph-311. It was sampled three times during the investigation — in 1945, 1954, and 1956. The water was only moderately contaminated compared to other well supplies in the area; moreover, during the period 1945-56 the mineral content of the water from well Ph-306 declined appreciably, which was contrary to the trend of most other water supplies. Although the character of the water from Ph-308 differed from that of neighboring supplies, it cannot be fully represented on the trilinear plot (Fig. 9) owing to the occurrence of significant concentrations of nitrate as a fourth anion. In water from well Ph-308, bicarbonate and sulfate were the chief anions, followed by chloride and nitrate, and the relative concentrations of each anion remained fairly constant through the range of concentration of dissolved solids. In water from well Ph-311, sulfate and chloride were the chief anions. Bicarbonate and chloride were the chief anions in water from well Ph-389 in 1953, and chloride and sulfate were the chief cations in 1954. The alkaline earths were the principal cations in water from well Ph-308, and the alkaline metals were the principal cations in water from well Ph-389.

These data suggest that the ground water being withdrawn from wells in the Five Mile Point area is a mixture of at least three components: (1) A highly mineralized sodium-chloride water which represents contamination from industrial brine wastes, (2) a moderately mineralized calcium bicarbonate and sulfate water which may represent contamination from miscellaneous industrial wastes, and (3) a water similar to the second but containing an appreciable concentration of nitrate which was derived probably from a local sanitary waste-disposal system.

Effects of Dilution by Induced Recharge

The compound effects of contamination from several inland sources and dilution by induced river recharge is evident in the analytical data from several well fields.

The Publicker Commercial Alcohol Co. well field at Greenwich Point, on the Delaware River, includes nine producing wells that tap the unconfined aquifer. Analyses are available of water from two of these wells, Ph-411 and 412. Figure 10 shows the range in the character of the water from well Ph-412 during the period December 1949 to September 1954. Until 1953 bicarbonate was the principal anion, accounting for from 56 to 90 percent of the anion equivalents and averaging about 75 percent. Chloride was the secondary anion in most samples, sulfate varied from a secondary anion to a minor constituent, and nitrate was a minor constituent in all but three samples which were collected in the period November 1950-January 1951. In general, the concentration of bicarbonate fluctuated more or less directly with the dissolved-solids content whereas sulfate varied inversely with dissolved solids. The cations were fairly evenly distributed, and the concentration of alkaline earths slightly exceeded that of sodium in most samples.

Analyses of four samples obtained in 1953 and 1954 differed greatly from those of samples obtained earlier. The chief features of the change in quality were a sharp decrease in bicarbonate, an equally sharp increase in chloride and nitrate, and an increase in the relative concentration of the alkaline earths (calcium and magnesium).

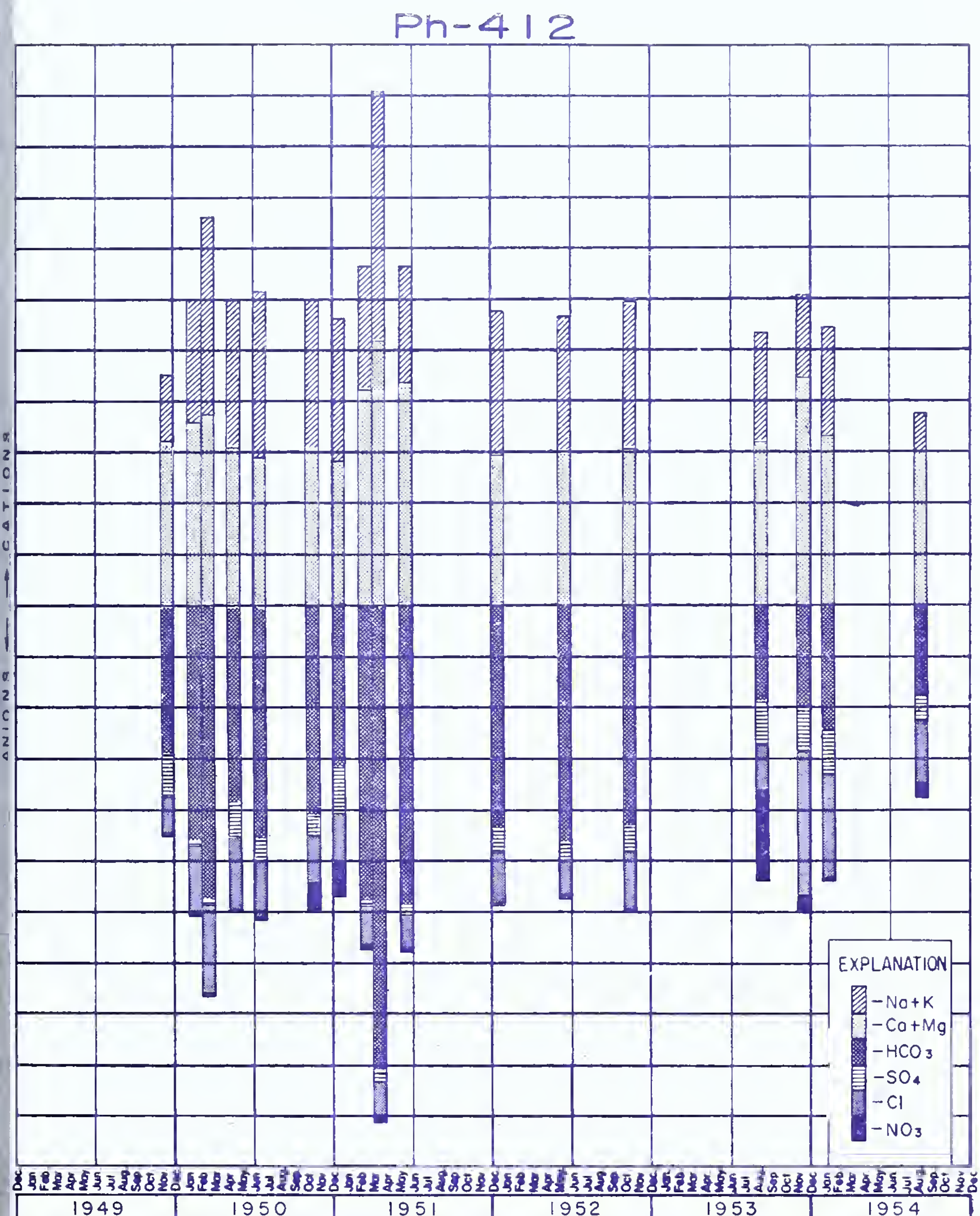


Figure 10.
Graph showing the changes in the composition of water from well Ph-412.

These data indicate that the water discharged from well Ph-412 is derived from at least three sources. One contributes a moderately mineralized alkaline-earth and bicarbonate-type water which includes sulfate as the secondary anion. This probably represents induced recharge from the Delaware River that is modified somewhat during its movement through the stream bed by moderate accretion of all dissolved constituents. A second source contributes a more mineralized, strong bicarbonate-type water containing approximately equal amounts of the alkaline earths and sodium, and a high concentration of iron. Chloride is a weak secondary anion, and sulfate is nearly absent.

This water may represent infiltrate through richly organic landfill material which would favor the operation of the sulfate-reduction process. A third source, which may be a combination of several sources, furnish moderately mineralized water characterized by the occurrence of chloride and nitrate as the dominant anions. This probably represents recharge contaminated by leakage of organic wastes from sanitary sewers or cesspools.

Owing to the proximity of the well to the Delaware River, induced recharge from the river is probably the primary source of water to the well under any condition of pumping. Recharge from secondary inland sources is intermittent owing to the effects of intermittent pumping of other wells that intercept recharge from these sources. The changes in the chemical character of water from well Ph-412 are primarily the result of changes in the pumping regimen of the subject well and several neighboring wells.

The influence of induced recharge from the Delaware River and the effects intermittent pumping has on the quality of water from Ph-412 are shown another way by the graphs of specific conductance versus time in Figure 11. Both graphs in Figure 11 show that seasonal fluctuations in the characteristics of the river water are reflected, after a time lag of about 5 months, in subdued but similar fluctuations in the composition of water from well Ph-412. The time lag represents the time required for water to move from the river to the well under the influence of the prevailing pumping gradient.

Graphs of the composition of water in well Ph-205, which is near the Delaware River adjacent to the Benjamin Franklin Bridge, show a somewhat different pattern of fluctuation. According to the subsurface contour maps (Pls. 9 and 15) the well penetrates the com-

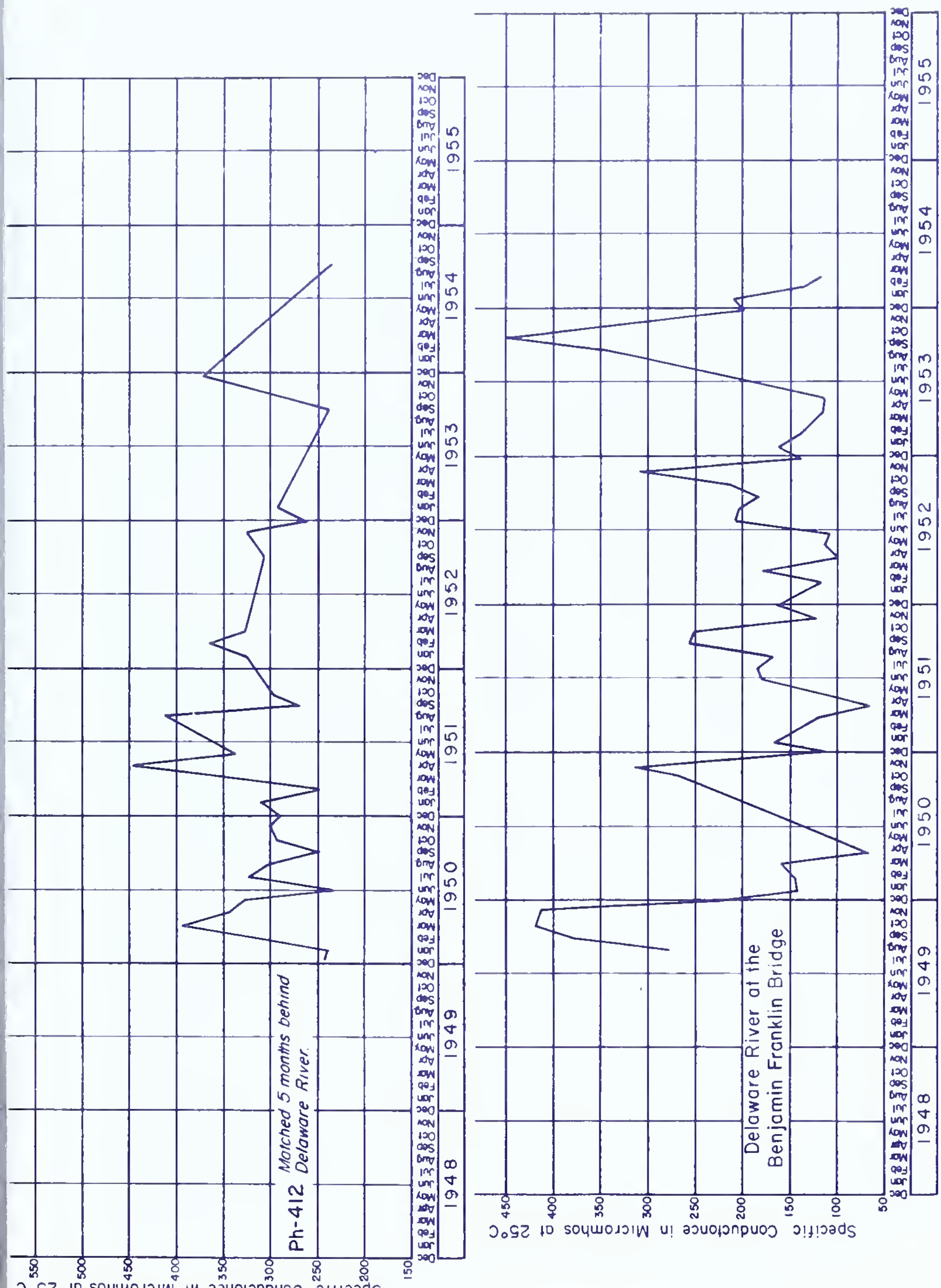


Figure 11.

Graphs showing the relation between changes in the specific conductance of waters from well Ph-412 and from the Delaware River at the Benjamin Franklin Bridge.

bined lower and middle confining clays and is finished in the Farrington member. However, the well is classed as a water-table well because the confining clay is thin and discontinuous in three directions from the well, thereby allowing almost uninhibited local recharge.

The changes in the composition of water of well Ph-205 are shown on the bar graph diagram in Figure 12 and the trilinear diagram in Figure 13, both of which indicate that induced recharge from the Delaware River has occurred. The earliest sample was a moderately mineralized water containing the alkaline earths as the principal cations, and sulfate and chloride in nearly equal concentrations (epm) as the principal anions. Nearly 4 years elapsed between the collection of the first and second samples, and in that period the dissolved-solids content of the water rose appreciably. The rise was due largely to an increase in chloride and the alkaline earths. From December 1949 through September 1950 the character of the water changed progressively. The concentration of chloride decreased appreciably, more or less in proportion to a moderate increase in sulfate and a slight increase in bicarbonate. The effect was a 20 percent decrease in dissolved solids. The linear relationship of the plotted data on Figure 13 (points 2 to 4 inclusive) indicates that during this period the composition of the water was dominated by a progressive change in the blending of water from two sources of recharge. One source was relatively highly mineralized, containing chloride as the principal anion; the other was moderately mineralized, containing sulfate as the principal anion.

The sources of the contaminants are not obvious. The chief source of chloride may be leakage or disposal of brine wastes from nearby meat packing plants. Sulfate may be derived from leaky sewers which would also be sources of nitrate.

Between September 1950 and January 1951 the character of the water from well Ph-205 changed markedly. As shown in Figure 12 dissolved solids declined appreciably, owing to a decrease in chloride and sulfate, but bicarbonate increased slightly. After January 1951, this trend continued on a subdued scale, its most obvious feature being a slight but persistent increase in bicarbonate. The concentrations of the other anions fluctuated considerably but tended to decrease slightly with time. The departure from the previous trend and the absence of a straight-line relationship for the post 1950 data on the trilinear diagram suggests that a third source of recharge is contribut-

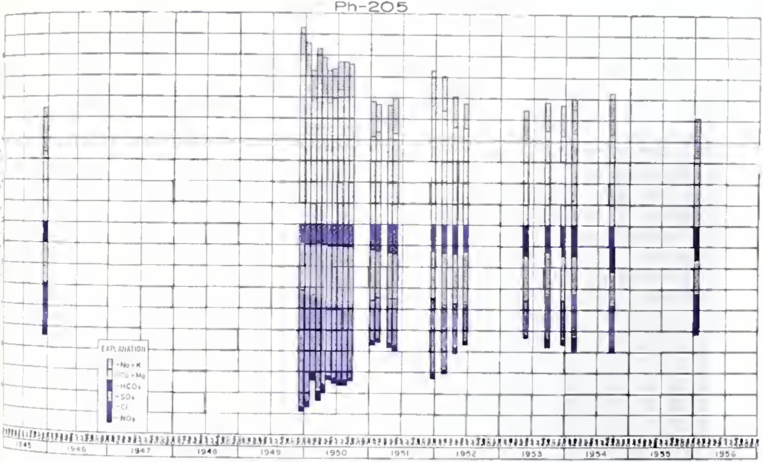


Figure 12
Graph showing the changes in the composition of water from well Ph-205

ing water to the system. The trilinear plot (Fig. 13) shows an erratic trend approaching point 13 which represents the average composition of Delaware River water. Because this trend is accompanied by a slight decrease in dissolved solids, it is probable that recharge from the river has occurred in recent years as a result of increased pumpage in the area.

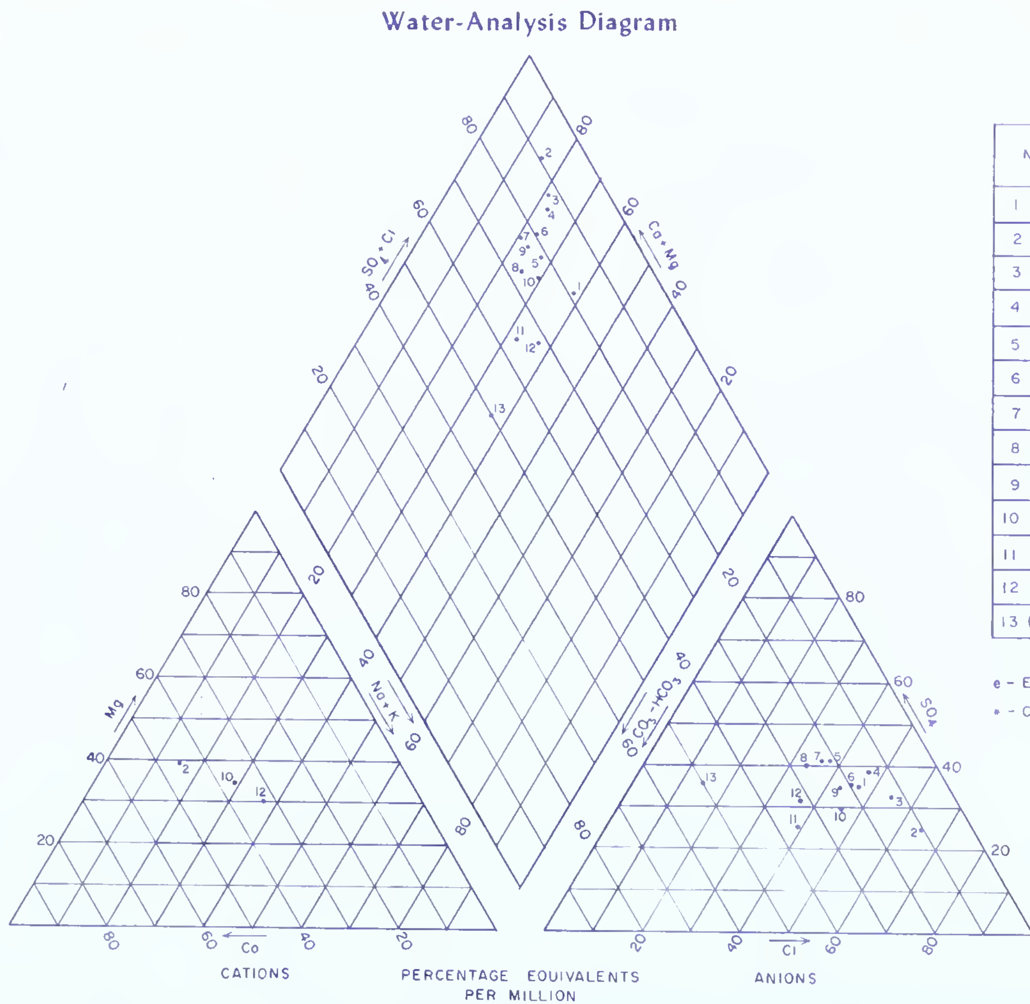
Analyses of water samples collected in 1954 and 1956 from wells Ph-202 and 203, which are downstream from well Ph-205 and well Ph-206, show an increase in dissolved solids in the downstream direction. This suggests either that river recharge is most effective in the area upstream from well Ph-205, or that contaminaton is most potent downstream, or both.

The effects of compound contamination from diverse sources is inferred in the analyses of water from wells Ph-175, 252, 281, and 288 (Table 12). The wells are widely separated, but they may be considered to have similar environments because all are remote from streams, areas of landfill, and known areas of contamination from industrial wastes. The contamination in the supplies they tap is derived presumably from various unrelated activities that are a part of the urban environment.

All of the samples were moderately mineralized, and they contained the alkaline earths as the primary cations with either bicarbonate or sulfate as the dominant anion. Contamination is evident from the dissolved-solids content, which ranges between about 400 and 500 ppm, and from the concentrations of the individual ions in solution. The degree of contamination is quite uniform, as each ion occurs generally in concentrations of about 10 to 15 times that of the native water.

Significance of Carbon Dioxide

Carbon dioxide has not been discussed in detail as a contaminant in the water-table aquifer owing to lack of analytical data on its occurrence. Its presence in significant concentrations in the water-table aquifer, however, is strongly inferred by two lines of indirect evidence. Firstly, in the section of this report entitled "Depreciation of the quality of water in the artesian system" carbon dioxide is shown to be an important contaminant in the subjacent artesian unit and, as such, must be derived from leakage from the water table. Secondly,



EXPLANATION

Number	Date	Dissolved solids (ppm)
1 (Ph-205)	12-12-45	320 e
2	12- 6-49	690 *
3	4- 6-50	520 e
4	8- 8-50	500 e
5	1- 8-51	340 e
6	2- 8-52	430 e
7	6- 9-52	350 e
8	5-25-53	360 e
9	9- 4-53	360 e
10	2- 8-54	330 *
11	9-24-54	370 e
12	1-20-56	300 e
13 (Delaware R.)	1944–1951	90 (average)

e - Estimated from specific conductance

* - Complete analysis.

Figure 13.
Trilinear diagram showing the changes in the chemical character of water from well Ph-205 and the Delaware River.

many well owners complain of corrosive water supplies, but routine laboratory analyses do not show sufficiently low values of pH to account for the reported corrosive character of the water. However. field determinations of pH of the supplies, made at the time of collection of the samples, commonly show the waters to be more acidic than do the subsequent laboratory analyses. This characteristic of unstable pH is typical of waters containing dissolved carbon dioxide, because the carbon dioxide in solution reacts with water to form carbonic acid which is highly corrosive toward iron, steel, and cement building material. The solution, however, is unstable, and carbon dioxide will pass from solution from a sample in storage causing an adjustment of pH toward an alkaline value.

An extreme case in point is illustrated by analyses of water from well Ph-108. The well was sampled in 1946, 1953, and 1956, and the composition of the water was virtually identical in the three samples. As determined in the laboratory, pH ranged from 6.9 in 1946 to 7.9 in 1953 and 8.1 in 1956, but a field determination of the latter showed a pH of 5.8 at the point of collection. Thus the 1956 sample, during 3-months storage, underwent a transition from an acidic to a basic solution, presumably owing to removal of carbon dioxide from solution. Similar adjustment in pH was reported for samples collected from a number of wells in 1956.

Carbon dioxide probably occurs as a contaminant in most of the unconfined ground water — especially in aquifers that are contaminated by liquid organic wastes or recharged by water moving through richly organic landfill such as was used to reclaim the tidal flats in south Philadelphia — because carbon dioxide is an end product of decomposition of organic material. Carbon dioxide is derived also from chemical reaction of the inorganic acids in industrial wastes with carbonate material in sediments through which the contaminated water moves. Where this occurs, however, the carbon dioxide is a minor contaminant because its corrosive character would be masked by the much more potent effect of the offending mineral acid.

Changes in Physical Quality

Changes in physical qualities of ground water in the unconfined aquifer occur also as a result of human activities. Temperature is the most important physical property of water from the standpoint of utilization, because it determines the efficiency of a water for

cooling use. As pointed out in the previous description of native quality, the temperature of natural ground water was quite uniform, varying no more than 1 or 2 degrees from the mean annual air temperature which is 56° F. for this area. No special temperature studies were made in the course of this investigation, but numerous measurements were taken in connection with the chemical sampling program. (See Table 12.) These measurements show that the ground-water temperature ranged from 54° to 75° F. and the average temperature determination was 61° F.

Areal Effects of Pumpage from the Artesian System

History of Development

The development of ground-water supplies from the regional artesian aquifer in the Philadelphia area did not begin on a significant scale until the early part of the twentieth century. During the initial stages of development, wells were not equipped with screens, and their yields were limited by the small area of the aquifer exposed to the well. Nevertheless, by 1920 the average daily pumpage from the artesian aquifer is estimated to have been approximately 5 mgd (million gallons per day). Most of the pumpage was concentrated in a narrow belt along the Delaware River from the Benjamin Franklin Bridge south to Greenwich Point (Pl. 5).

The subsequent growth of water-using industries and improvements in well-construction methods contributed to a steady increase in pumpage, so that by 1940 the average daily pumpage from the artesian aquifer was 15 mgd. From 1940 to 1945 the rate of withdrawal increased rapidly to 23 mgd, owing to the expansion of local industries and other establishments engaged in the war effort. Much of this increase resulted from the installation of 8 production wells to supply 5 mgd of potable water to the U. S. Naval Base on League Island. Also, a sizeable increase in pumpage occurred at Greenwich Point where several new wells were drilled for the Publicker Commercial Alcohol Co.

Pumpage from the artesian aquifer declined in 1946 and 1947 owing to the lull in industrial activity immediately following World War II. In the next few years, however, the demand for ground water was renewed, and by 1951 the rate of withdrawal again averaged 23

mgd. From 1951 until late 1953 the volume of pumpage changed very little, but since 1953 the rate of pumping has declined because of the rise in treatment costs and the availability of adequate supplies from the municipal water-supply systems. In 1956 withdrawals from the artesian aquifer in south Philadelphia averaged 18 mgd.

Recharge and Movement in Relation to Pumpage

The effect of early development on the movement of ground water in the artesian aquifer is shown in Figure 14, which is a schematic representation of the piezometric surface of the Farrington sand during the early 1920's. Figure 14 is a modification of Figure 7, which is based on water-level measurements made between 1915 and 1924. The positions of pumping centers are clearly indicated by the closed contour lines that define the cones of depression in the piezometric surface. The contour lines show the general direction of the hydraulic gradient and, because ground water flows down gradient or at right angles to the contour lines, they indicate the general directions of flow within the aquifer.

Comparison of figures 14 and 7 indicates that the pattern of ground-water flow through the artesian system in 1920 was radically different from that prior to the onset of pumping. The major change in the direction of ground-water movement occurred in the Greenwich Point trough where the heaviest withdrawals were concentrated. Ground water that had been moving in a northerly direction through the artesian aquifer toward areas of natural discharge was intercepted by the cones of depression in the central and southern sections of the trough. Similarly, much of the recharge entering the artesian system at the head of the trough and flowing southeasterly was intercepted by a cone of depression in that area. Another cone of depression caused by pumpage east of Washington Square evidently induced some recharge from the Delaware River. In addition to these changes, the decrease in artesian pressure at each of the centers of pumping favored leakage through the upper confining layer from the overlying water-table aquifer.

Unlike the area of the Greenwich Point trough, the pattern of ground-water movement in the area of the League Island trough was changed very little by 1920, as shown by Figure 14. A shallow cone of depression just north of League Island Park altered the natural local

hydraulic gradient and pirated some of the flow of ground water through the artesian aquifer, but the natural hydraulic gradient was not changed significantly beyond a radius of about 2,000 feet from the center of pumping.

Figure 15 shows the approximate configuration of the piezometric surface of the artesian aquifer in 1940. The effect that the progressive increase in the rate of withdrawal between 1920 and 1940 had on the movement of ground water can be determined by comparing Figures 14 and 15. In the Greenwich Point trough, the additional declines of water level that accompanied the increased withdrawals of ground water caused the local hydraulic gradient to be greatly increased. This, in turn, increased the rate of flow of ground water toward the centers of pumping but did not alter significantly the direction of movement.

On the other hand, changes in the distribution of pumping in the area of the League Island trough caused significant changes in the direction of ground-water movement in that area. The development of a shallow cone of depression on the north side of Mustin Airfield reversed the direction of natural movement for some distance north and west from the center of pumping and increased the northward gradient south of the center of pumping. Elsewhere in the area of the League Island trough intermittent pumping from several wells caused erratic changes in the direction and rate of movement, but these effects were local and short-lived.

The effects of heavy withdrawals from the artesian aquifer during the period of World War II (from 1941 to 1945) are shown by Figure 16, a piezometric map based on 1945 water-level measurements. The pattern of movement in the area of the League Island trough was dominated by the effects of pumpage at the U. S. Naval Base. The hydraulic gradients that were developed promoted the migration of water southeastward from the Schuylkill River and southward from the northern end of the area of the League Island trough. South of the locus of pumping the natural hydraulic gradient was steepened so that a larger volume of water was induced to move northward through the aquifer. Also, the head differential between the artesian aquifer and the overlying water-table aquifer was increased, probably causing a corresponding increase in the amount of water moving downward through and around the confining beds into the artesian aquifer.

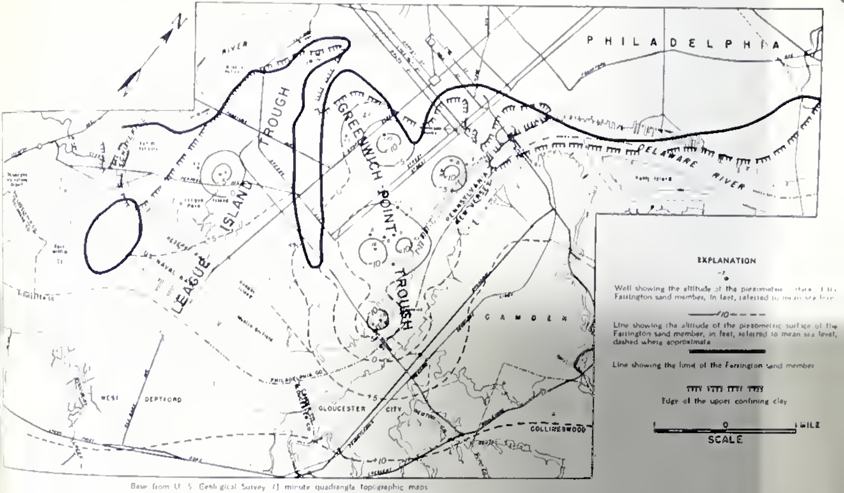


Figure 14.
Map of the Philadelphia area showing a schematic representation of the piezometric surface in the Farrington sand member of the Raritan formation during the early 1920's.

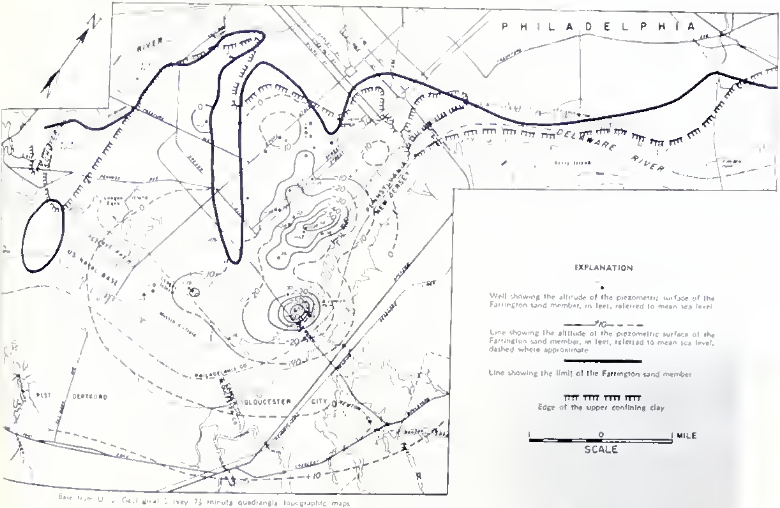
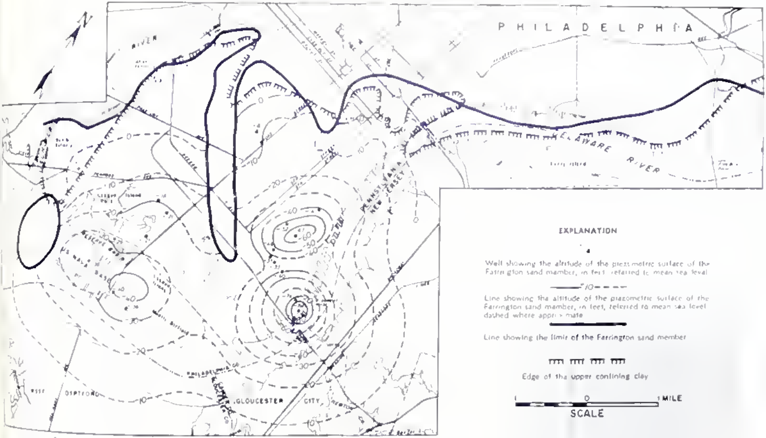
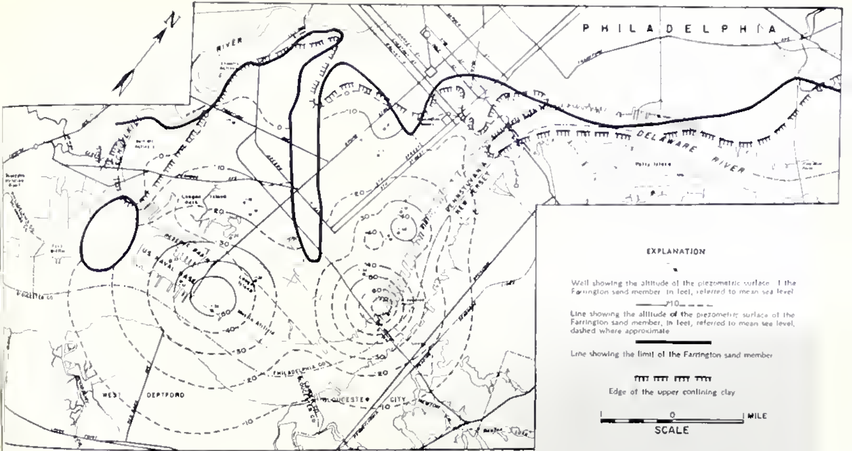


Figure 15
Map of the Philadelphia area showing a schematic representation of the piezometric surface of the Farrington sand member of the Raritan formation in 1940.



Base from U. S. Geological Survey 7½ minute quadrangle topographic maps

Figure 16.
Map of the Philadelphia area showing a schematic representation of the piezometric surface of the Farrington sand member of the Raritan formation in August 1945.



Base from U. S. Geological Survey 7½ minute quadrangle topographic maps

Figure 17.
Map of the Philadelphia area showing a schematic representation of the piezometric surface of the Farrington sand member of the Raritan formation on March 24, 1954.

In the areas of the Greenwich Point and Washington Square troughs, the direction of ground-water movement remained relatively unchanged. However, the rate of flow of ground water from the various sources of recharge was directly influenced by changes in the rate of pumping.

Since 1945 the direction of ground-water movement has changed very little, as evidenced by Figure 17. This map, unlike the earlier ones, is based on water-level measurements made in about 30 observation wells in a single day. In constructing the map various factors of the hydrologic environment were taken into account. For instance, the volume and location of heavy pumping are fairly well known in the Philadelphia area. This information was used in the construction of the map by arbitrarily drawing concentric contour lines around the centers of pumping and adjusting the spacing of these contour lines to make them agree with the water-level measurements made outside the steep parts of the cones of depression. Therefore, the map is highly interpretive, but the direction of ground-water movement, as shown, is believed to be sufficiently accurate to permit identification of the major sources of recharge.

From the foregoing analyses of the movement of water in relation to pumpage it is apparent that the water discharged from wells tapping the artesian aquifer in the Philadelphia area is derived from three principal sources. During the initial stages of pumping the water was obtained chiefly from storage within the aquifer and a diversion of natural discharge. As pumping continued and water levels were progressively lowered, hydraulic gradients were established that favored movement of water downward from the overlying water-table aquifer — either by direct percolation in those areas where the two aquifers merge or by leakage through the confining layers separating the aquifers. Eventually gradients were established that induced recharge from the Delaware River and its tributaries.

Effect on Water Levels

Beginning in 1943, water-level measurements were obtained from a number of observation wells tapping the artesian aquifer in south Philadelphia to determine as accurately as possible the character and magnitude of water-level fluctuations. Periodic measurements of water level were made in some observation wells, and continuous measurements were made in others by means of water-level recorders. Hydro-

graphs were plotted from these measurements to determine the exact trend of water levels in the various aquifers. (See Figs. 18-22.) The continuous water-level records have been especially useful in evaluating short-term water-level fluctuations.

Hydrographs of selected observation wells in the U. S. Naval Base are shown in Figure 18. The hydrograph of observation well Ph-20 shows the fluctuations of the water level in the Farrington sand member caused by changes in pumpage from the Naval Base wells. The hydrographs of observation wells Ph-12 and Ph-13 (about 1,000 feet apart), tapping the Sayreville sand and the Pleistocene deposits, respectively, show the response of the overlying aquifers to pumpage from the Farrington sand member. The response of the Sayreville is slightly greater than that of the Pleistocene deposits, but the trend in all three aquifers is similar.

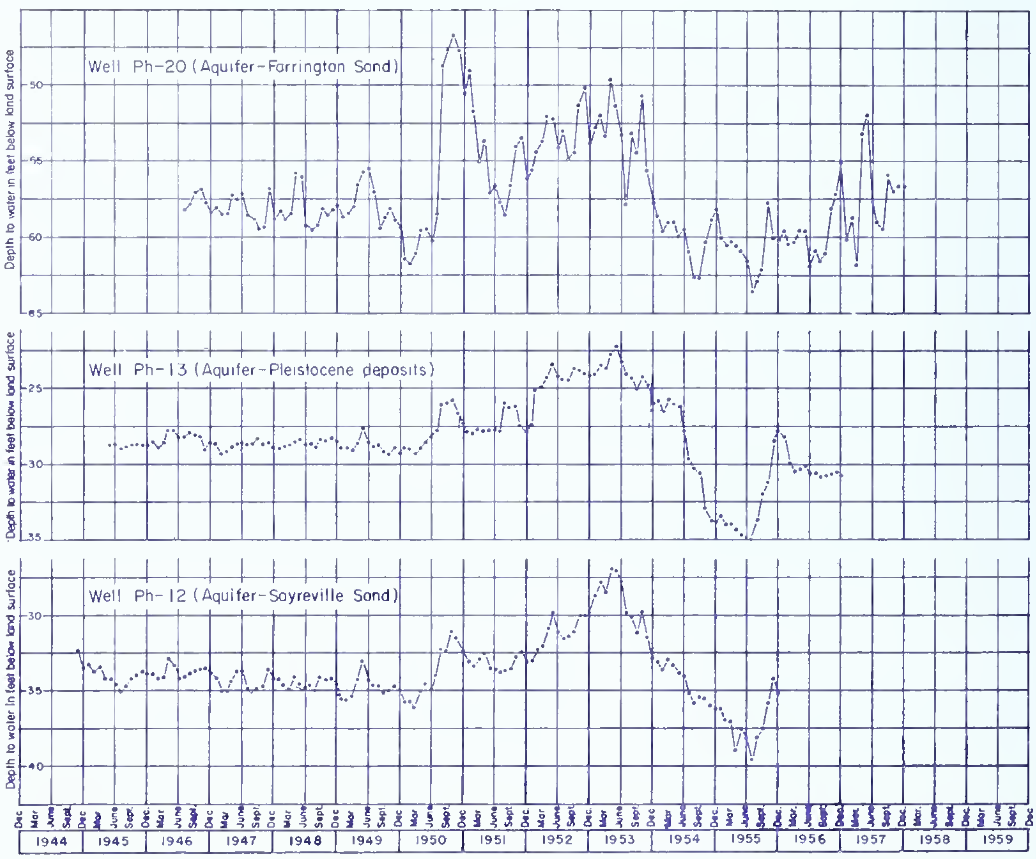


Figure 18.

Hydrograph showing the fluctuations of water level in wells at the U. S. Naval Base, Philadelphia, Pa.

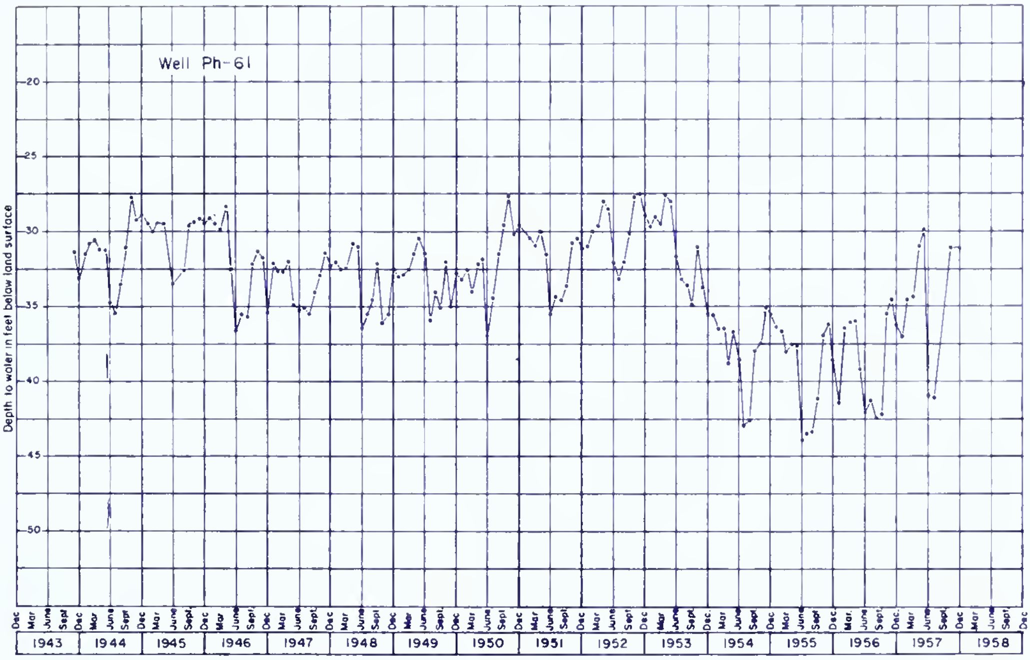


Figure 19.

Hydrograph showing the fluctuations of artesian head at League Island Park in the League island trough, Philadelphia, Pa.

The hydrograph of well Ph-61 (Fig. 19), in League Island Park, shows the combined effects of pumpage from a distant and a nearby source. The most conspicuous fluctuations are caused by the intermittent pumping of nearby well Ph-62, less than 500 feet away. But the principal fluctuations, which determine the overall trend of the hydrograph, are caused by the continuous pumping of wells at the U. S. Naval Base, some 3,000 feet away. It is possible to identify these effects separately on the hydrograph because the nearby well is pumped only during the summer months to supply the League Island Park swimming pool.

Fluctuations of artesian pressure in the Point Breeze trough are shown by the hydrograph for well Ph-30 at the Philadelphia International Airport. (See Fig. 20.) The nearly unchanging water levels in this well are probably due to the remoteness of this well from any significant area of pumpage. The magnitudes of the fluctuations are no doubt similar to those that occurred in the regional artesian aquifer prior to development of the aquifer.

The hydrographs for wells Ph-248 and 249 (Fig. 21) illustrate the effect of pumpage from the artesian aquifer in the northern part of the Greenwich Point trough. These hydrographs are a fairly reliable indication of the changing rates of industrial pumping throughout the Philadelphia area. As shown by the hydrograph of well

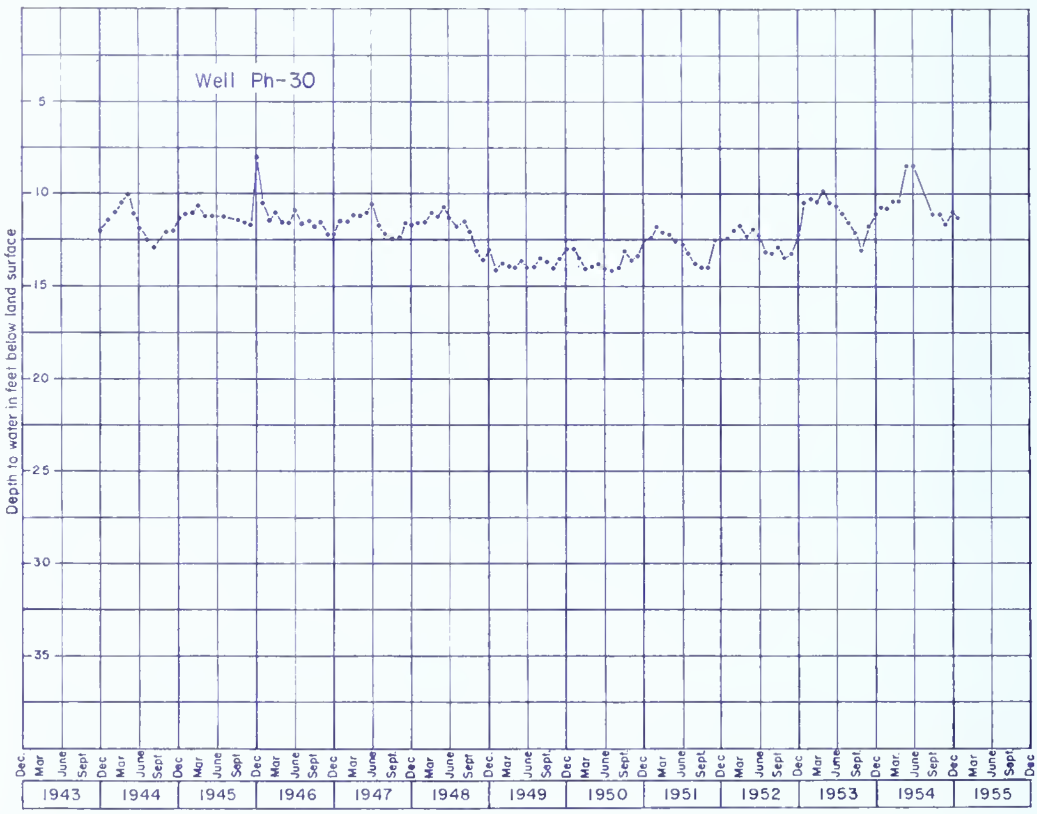


Figure 20.
Hydrograph showing the fluctuations of artesian head at the Philadelphia International Airport.

Ph-248, the largest pumping rate probably occurred prior to 1945, when maximum production was required by the war effort. Subsequent changes in rates of pumping are indicated by alternately rising and declining water-level trends.

Fluctuations of water levels in well Ph-177 (Fig. 22), which taps the artesian aquifer in the Washington Square area, are typical of those in observation wells that are close to a source of surface recharge — in this instance, the Delaware River. The amplitude of the fluctuations caused by pumping are not as great as in other parts of the

artesian system owing to the balancing effect of the surface reservoir. The abrupt rise shown on the hydrograph in late 1955 was caused by shutting down a nearby well.

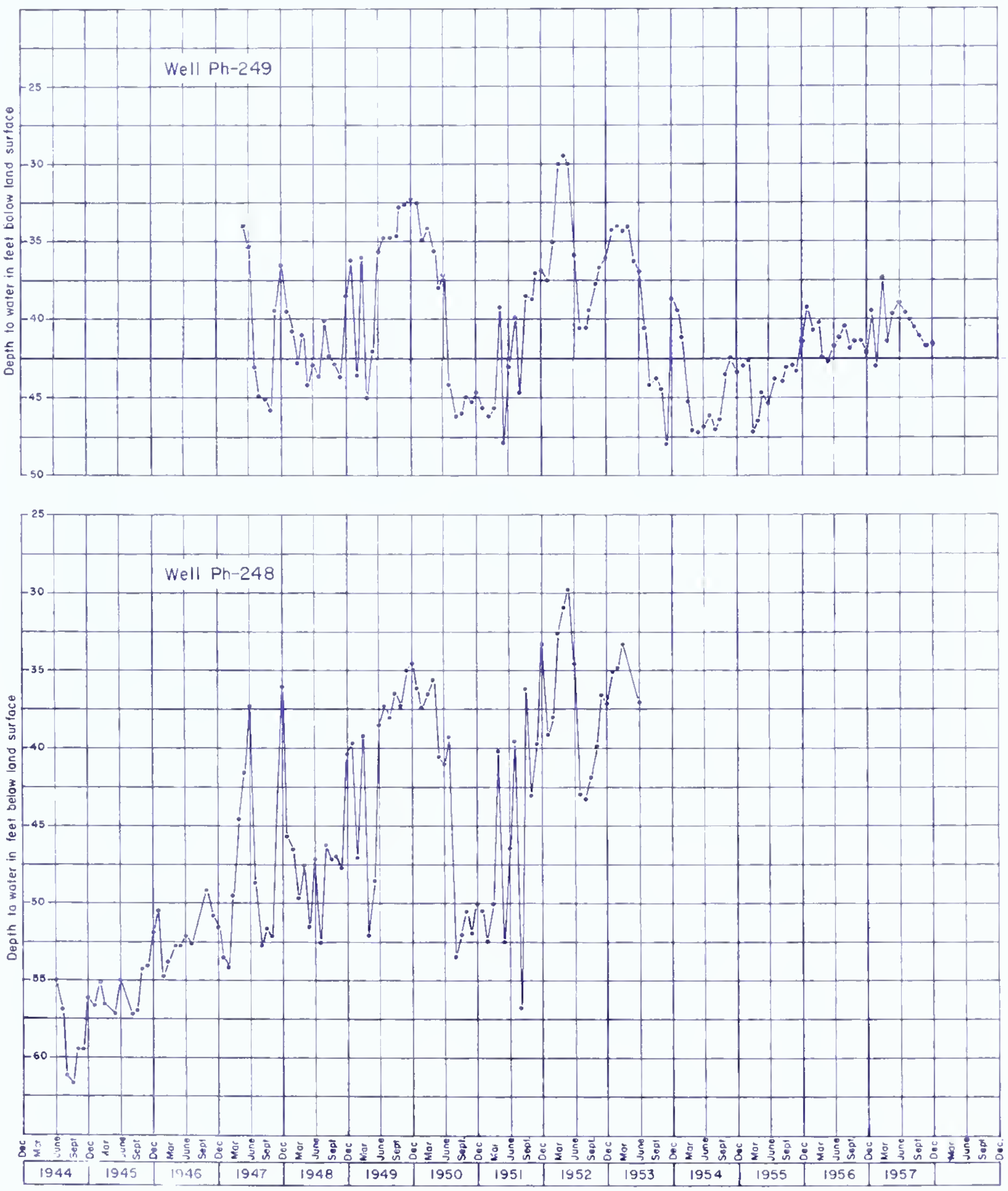


Figure 21.
Hydrograph showing the fluctuations of artesian head in the Greenwich Point trough.

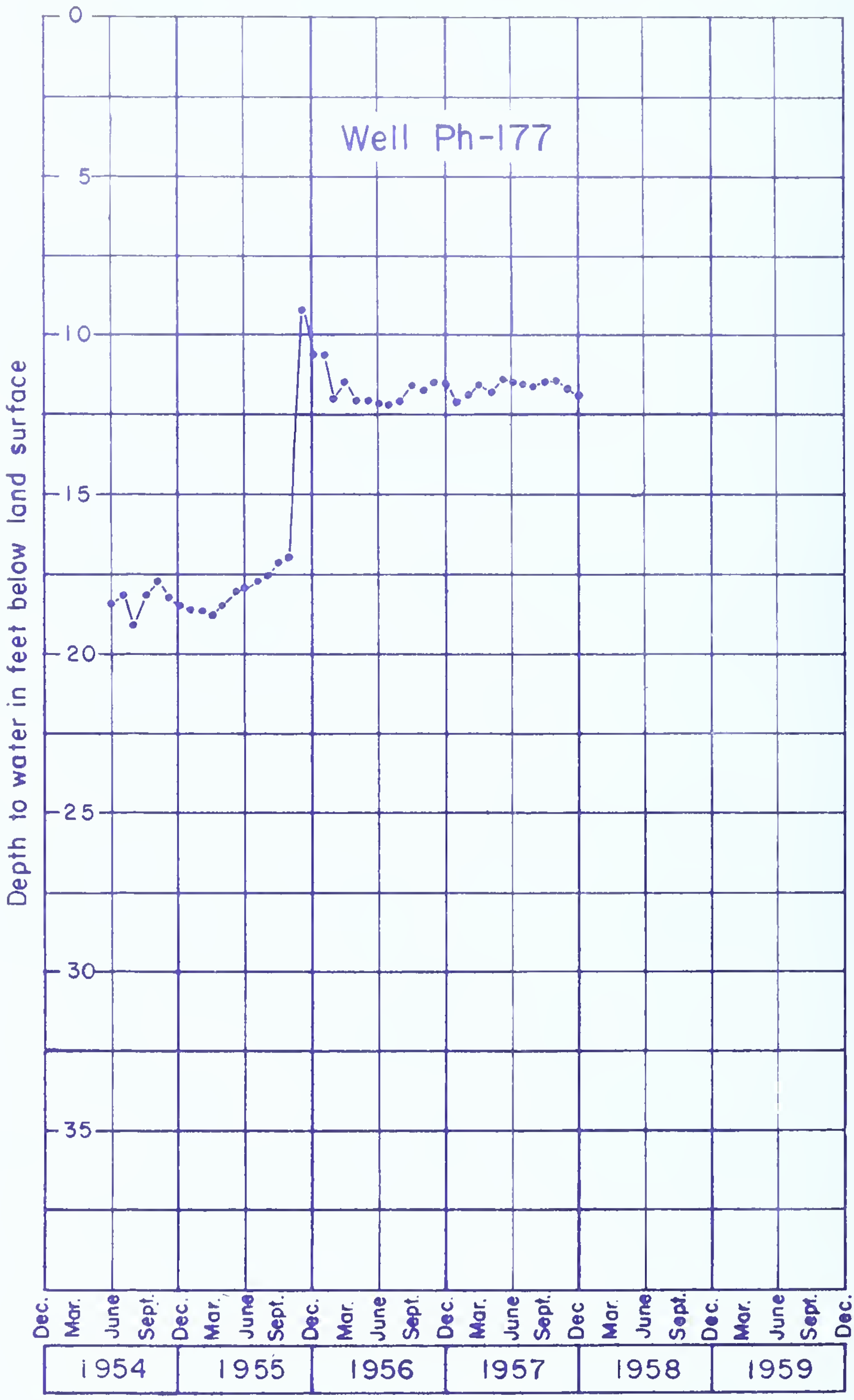


Figure 22.
Hydrograph showing the fluctuation of artesian head in the Washington Square trough.

Depreciation of the Quality of Water in the Artesian System

It has been suggested that urban development has resulted in gross contamination of the water-table aquifers, and that subsequent exploitation of water supplies from the artesian aquifer has caused sufficient decline in artesian head to induce recharge from the water-table aquifers. The composite effect has been progressive widespread contamination of the ground water in the artesian system.

Changes in the Farrington Sand Member

Table 12 gives analyses of water from 60 wells that tap the Farrington member in south Philadelphia. Except for the earliest analyses for wells Ph-1, 2, 3, 4, 5, 7, and 8 at the Naval Base, all of these analyses show effects of contamination. According to the most recent analyses from all the wells tapping the Farrington sand member, dissolved solids range from 114 to 2,220 ppm and average, about 430 ppm. The alkaline earths are the principal cations, and sulfate and bicarbonate the chief anions. Chloride is an important constituent of all samples, and nitrate is an important constituent of some samples. From the standpoint of utilization, iron and the alkaline earths are the chief contaminants. The concentration of iron ranges for 0.09 to 25 ppm, and exceeds 1 ppm in 22 of the 60 samples tested. Hardness, caused by large concentrations of the alkaline earths, ranges from 34 to 1,480 ppm and typically exceeds 150 ppm. Thus, contamination has appreciably lessened the economic utility of these waters, most of which must now be classified as marginal or submarginal supplies according to the standards given in Tables 2 and 3.

Unlike conditions in the unconfined aquifers, the mineral constituents in the Farrington member, with the exception of iron, are distributed in a fairly well-defined areal pattern. This pattern approximates the pattern of distribution of hydraulic head but is modified from that form by differences in the character of recharge. This is illustrated by the isoquality maps in Plates 21 and 22, prepared from the most recent available data for each well. They depict only general conditions in the area, and should not be used to predict the precise quality of water at a potential well site because the density of data are not sufficient to show all areal changes, especially those caused by local recharge.

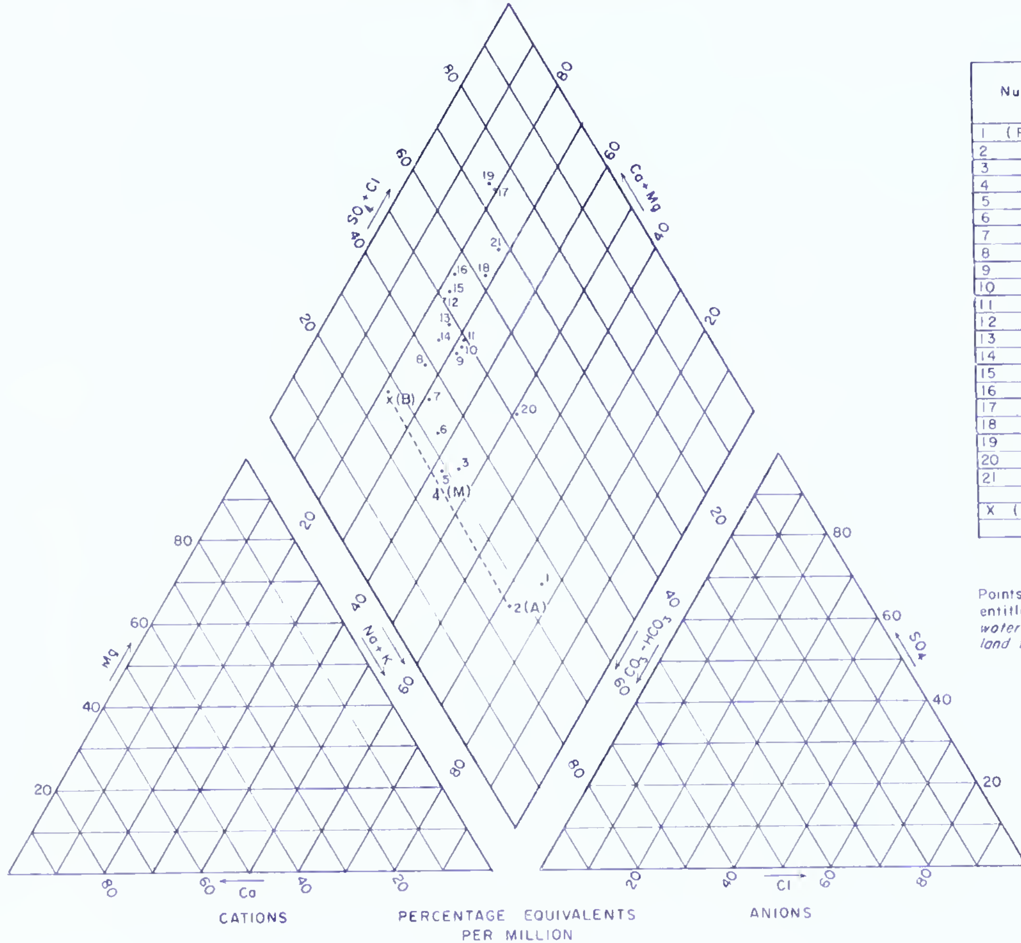
League Island trough area

In the League Island trough the most mineralized waters in the Farrington member occur at the head of the trough, near the sub-outcrop area, where the member is hydraulically continuous with the severely contaminated water-table aquifer. Wells Ph-83 and 93 yield water similar in character and concentration to that from the overlying unconfined aquifer. The water is a highly mineralized (1,500 to 2,500 ppm) alkaline-earth sulfate type commonly high in chloride, and frequently high in nitrate and iron. The mineral content and the relative concentration of sulfate in water from wells decreases downdip which is also down the hydraulic gradient. These changes are clearly shown on Plate 21 and 22 by the tonguelike form of the contours that extend from the head of the trough to the center of pumping at the Naval Base.

Another major source of contaminated recharge is the subsurface recharge area of the Farrington member bordering the western margin of the League Island trough. Recharge from that area is indicated by analyses of water from wells Ph-43, 44, 62, and 6. The water is a moderately mineralized (300 to 400 ppm) alkaline-earth bicarbonate type that has a lower dissolved-solids content and a lower relative concentration of sulfate than recharge from the north. The areal effect of recharge from that area is marked on Plates 21 and 22 by distinct tonguelike contours that extend from the suboutcrop areas toward the center of pumping in the Naval Base where they coalesce with the tongues representing movement from the north.

The changes in quality of water from wells along the hydraulic gradent are due chiefly to blending of the water migrating downdip with local recharge and with native water. The importance of local recharge increases updip, varying more or less inversely with the thickness of the confining clay (Pl. 18). Conversely, blending with native water is currently significant only in the vicinity of, and downdip from, the center of pumping at the Naval Base, as the native water has been discharged from storage updip by previous pumping. A contributing cause of the change in quality may be past changes in the character of recharge entering the aquifer in the subsurface-recharge areas. Such effects probably would be so gradual as to escape notice, and in any event cannot be evaluated with available data.

Water-Analysis Diagram



EXPLANATION

Number	Date	Dissolved solids (ppm)
1 (Ph-1)	4- 8-43	129
2	2-15-44	124
3	10- 3-44	134.4
4	11-15-45	148
5	3-28-46	-
6	8-29-46	-
7	2-28-47	177
8	7- 7-47	173
9	10- 8-48	225
10	2-18-49	225
11	7-28-49	256
12	2-23-50	-
13	12-28-50	294
14	2-28-51	265
15	11-26-51	270
16	4-28-52	284
17	12-23-53	-
18	2-19-54	-
19	10- 8-54	-
20	1- 7-56	511
21	7-28-57	559
X (Ph-14)	-	-

Points A, B, and M discussed in section entitled: *"Depreciation of the quality of water in the artesian system—League Island trough area."*

Figure 23.
Trilinear diagram showing the changes in the chemical character of water from well Ph-1 (1943-58).

Regardless of local anomalies, the general pattern in the League Island trough is one of decreasing concentration of dissolved solids down the hydraulic gradient toward the center of pumping at the Naval Base.

A nearly complete history of contamination of ground water in the Farrington member is documented in the quailty-of-water records for several wells at the Naval Base. The Naval Base well field includes 12 wells that tap the Farrington member of the artesian system. They are identified in illustrations and tables of this report as wells Ph-1 through 8, and 25 through 28. The first group of wells has been sampled more or less periodically since 1943, with the exception of well Ph-5 which was adandoned after a brief period of pumping owing to a sharp increase in the iron content of the water after pumping began.

All of the wells except well Ph-6 yielded essentially native water at the inception of pumping. Well Ph-6 is close to the suboutcrop area of the aquifer and showed effects of recharge from that area. The native water was a moderately mineralized sodium-bicarbonate type, slightly alkaline in reaction and containing only traces of nitrate and iron. But with passage of time — intervals ranging from a few months to several years for the individual wells — the mineral character and concentration of the water changed as the native water was discharged from storage and the wells commenced to yield water derived partly from local recharge and partly from water migrating downdip from the two major subsurface-recharge areas. Sequential analyses of water from the wells are given in Table 12. The changing character of water from well Ph-1 is shown in the trilinear diagram in Figure 23 and the changes in concentration of several chief mineral constituents and total dissolved solids are shown on the graph in Figure 24.

Water from well Ph-1 has undergone the most complete transformation of composition known in the area. Data given in Figures 24 and 25 show essentially two stages of contamination for well Ph-1. The first stage began in late 1944 and featured a transition in chemical character to an alkaline-earth bicarbonate-type water. This was indicated by a moderate increase in the concentration of alkaline earths,

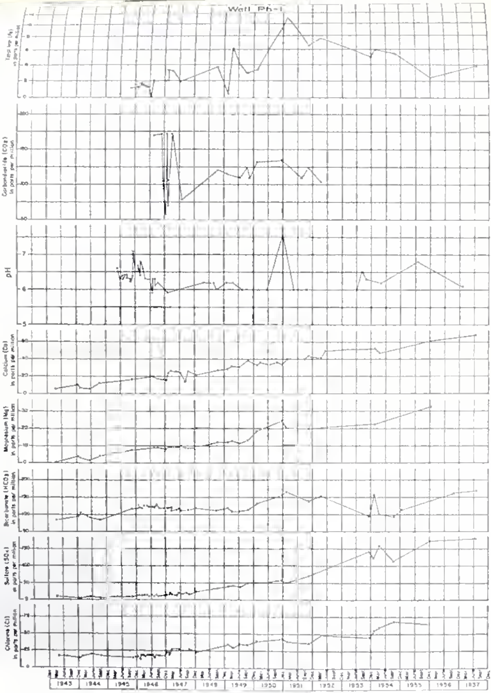


Figure 24

Graphs showing the variation of chemical constituents in water from well Ph-1 (1943-57)

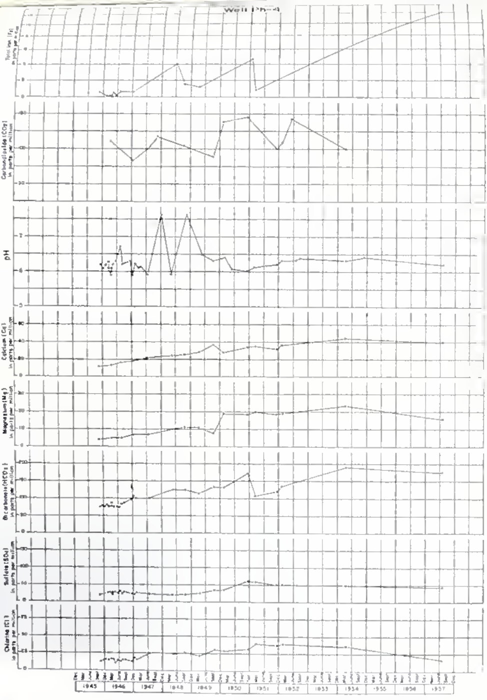


Figure 25

Graphs showing the variation of chemical constituents in water from well Ph-4 (1945-57).

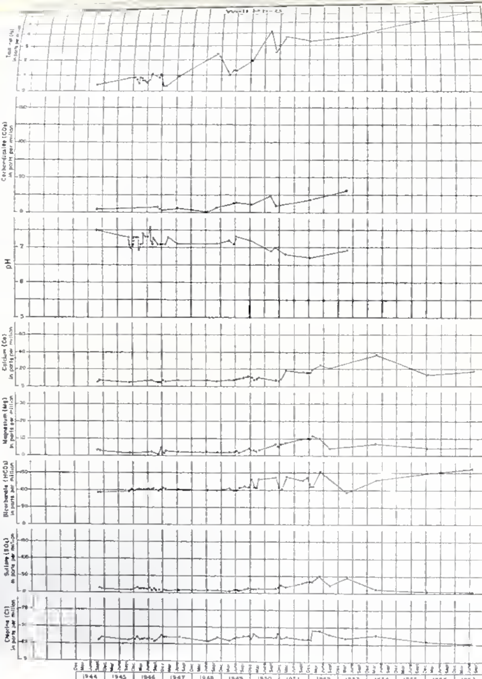


Figure 26.
Graphs showing the variation of chemical constituents in water from well Ph-8 (1944-57).

bicarbonate, and dissolved solids and was accompanied by a marked increase in iron and nitrate. Dissolved carbon dioxide presumably increased also, but it cannot be demonstrated graphically because the first determinations of carbon dioxide were made in late 1945. During this period the pH of the water changed from a neutral or slightly alkaline value to a slightly acidic value.

The constituents strongly suggest they are derived from vertical leakage from the overlying unconfined aquifers at the Naval Base. According to analytical data given in Table 12 for wells Ph--13, 14, 15, and 16, water from the unconfined aquifers is a moderately mineralized alkaline-earth bicarbonate type, slightly acidic in reaction, and containing extremely high concentrations of iron and high concentrations of carbon dioxide. Water of this composition is unique for the area, and if introduced as recharge would account for the first stage of contamination of the water in well Ph-1.

The feasibility of local recharge is demonstrated by the analyses of water from well Ph-5 (Table 12). The well yielded native-type water when it was placed in service, but soon after pumping began the water changed in character to an alkaline-earth bicarbonate type having a relatively high concentration of iron. This rapid transition in composition is believed to have been caused by local infiltration from the overlying unconfined aquifers for the following reasons: The driller's log for well Ph-5 shows no well-defined thick clay as was found in other logs on the Naval Base. Instead there are listed 54 feet of "gray and brown sand and clay" and 21 feet of "sandy clay" above the Farrington member. It is probable, then, that considerable vertical leakage could occur in the vicinity of well Ph-5, and conceivably these conditions could be duplicated elsewhere in the area. Leakage from the unconfined aquifers may occur also through improperly sealed abandoned wells which penetrated the unconfined and confined aquifers.

The trend associated with the first stage of change of composition of well Ph-1 continued until late 1946, when the concentration of the individual constituents approached equilibrium with the hydrodynamic environment.

The relative proportions of the native water and infiltrate from the unconfined aquifer yielded by well Ph-1 during this period of stability can be calculated using the method described by Piper (1944). On any

field of the trilinear diagram let M be the plotted position of a blended water which lies on a straight line joining the plotted position of components A and B. Then let E_a equal the concentration of component A in equivalents; $_a$ equals the intercept between the plotted points A and M measured at any convenient scale; $_b$ equals the intercept between points B and M; V_a equals proportional value in mixture M having composition A; and V_b equals proportional value of water having composition B. Thus,

$$V_a = \frac{(_b)\ (E_b)}{(_a)\ (E_a) + (_b)\ (E_b)} \quad (1)$$

and

$$V_b = \frac{(_b)\ (E_a)}{(_a)\ (E_a) + (_b)\ (E_b)} \quad (2)$$

Applying this method to the data for well Ph-1 (see Fig. 23), the native-quality water, corresponding to component A, is represented by point 2. The infiltrate from the unconfined aquifer, corresponding to component B, is represented by point X (a plot of the data for well Ph-14). Then point M, or the mixtures of the two waters, is represented by point 4. Solving equations 1 and 2 for total equivalents:

$$V_a = \frac{(2.6 \text{ cm})\ (6.8 \text{ epm})}{(3.3 \text{ cm})\ (4.6 \text{ epm}) + (2.6 \text{ cm})\ (6.8 \text{ epm})} = 30\% = 0.54 \times 100 = 54\%$$

and

$$V_b = \frac{(3.3 \text{ cm})\ (4.6 \text{ epm})}{(3.3 \text{ cm})\ (4.6 \text{ epm}) + (2.6 \text{ cm})\ (6.8 \text{ epm})} = 70\% = 0.46 \times 100 = 46\%$$

According to Piper (1944) these values for the relative proportions of components A and B present in the mixture M can be verified by solving equation 3 below for the individual constituents and comparing the computed results with the analytical data for a well. This was done with the data for well Ph-1 on November 15, 1945 (Table 12).

$$C_m = (C_a)\ (V_a) + (C_b)\ (V_b) \quad (3)$$

in which C_m equals the concentration (epm) of a given constituent in the blended water; C_a equals the concentration of the constituent in the native water; and C_b equals the concentration in the overlying unconfined aquifer.

$$C_{Ca} = (0.37)(0.54) + (1.7)(0.46)$$
$$= 0.200 + 0.782 = 0.982 \text{ epm or } 20 \text{ ppm Ca}$$

$$C_{Mg} = (0.26)(0.54) + (1.1)(0.46)$$
$$= 0.140 + 0.506 = 0.646 \text{ epm or } 7.9 \text{ ppm Mg}$$

$$C_{Na+K} = (1.6)(0.54) + (7.1)(0.46)$$
$$= 0.864 + 0.350 = 1.214 \text{ epm or } 28 \text{ ppm Na+K}$$

$$C_{HCO3} = (1.7)(0.54) + (2.3)(0.46)$$
$$= 0.918 + 1.05 = 1.97 \text{ epm or } 120 \text{ ppm } HCO_3$$

$$C_{SO4} = (0.13)(0.54) + (0.10)(0.46)$$
$$= 0.070 + 0.046 = 0.116 \text{ epm or } 5.6 \text{ ppm } SO_4$$

$$C_{Cl} = (0.49)(0.54) + (0.81)(0.46)$$
$$= 0.265 + 0.373 = 0.638 \text{ epm or } 23 \text{ ppm Cl}$$

The computed values for calcium, magnesium, sodium, and bicarbonate show reasonably close agreement with the laboratory determination for the sample represented by point 4 on Figure 23. As these are the major ocnstituents of the virgin waters, the values of V_a and V_b probably can be accepted as accurate at least to the indicated order of magnitude. The computed values for sulfate and chloride do not correspond so well to the laboratory determination. But these are minor constituents in these samples and their concentration in both components are more variable than the major constituents, which probably accounts for the discrepancies between the computed results and the analytical data.

It is significant that the concentration of iron in the water from Ph-1 did not increase in proportion to the increase in the volume of local leakage from the unconfined aquifer. The concentration of iron was 1.2 ppm in the sample which was used for the sample calculation, whereas it should have been 150 ppm or more in a simple mixture comprising 46 percent water from the unconfined aquifer and 54 percent native water. Evidently the clay of the confining bed interferes with the transport of iron in the infiltrate. The principal mechanism for removal of iron probably is preferential absorption by certain constituents of the clay, However, the physical chemistry of iron is not too well understood, and has not been studied in detail in this environment; so, other factors may also be involved in precipitation of iron from solution or flocculation of iron colloids.

Iron in water in the Farrington member may owe its occurrence to any or all of several factors. The simplest explanation is chance—that is, a small fraction of the iron in the water from the unconfined aquifer retained its mobility through the clay because it did not encounter a precipitating or adsorptive agent. An alternate explanation assumes that the iron in the unconfined aquifer occurs in several forms. Most of the iron may occur as colloidal ferric hydroxide which would be highly susceptible to adsorption or precipitation in the clay. Some of the iron might occur as ferrous ions in solution which probably would be less susceptible to precipitation or absorption so long as the carbon dioxide content were not diminished. Some iron may occur with organic colloids and in this form would be least susceptible to removal during movement through the clay. Thus, it can be postulated that all of the collodial ferric hydroxide is removed and that only the other forms of iron retain mobility through the clay.

Iron in water from the Farrington member may be derived also from a minor component of unaltered leakage from the unconfined aquifer which occurs through improperly sealed abandoned wells, or by solution of iron indigenous to the member by carbon dioxide-rich waters. The latter is not likely to be a principal source because it requires the concentrations of iron and carbon dioxide to show similar fluctuation which has not necessarily occurred, according to analyses of water from the Naval Base wells.

The second stage of contamination in Ph-1 was superimposed on the first, beginning in early 1947. It featured an erratic transition in chemical character toward an alkaline-earth sulfate-type water and a marked increase in dissolved solids. It was noted in the early years (1947-51) by a progressive increase in all constituents except bicarbonate and the alkalies, and a further decline in pH (Fig. 24). This relatively smooth trend gave way in later years (1951-56) to erratic fluctuations but overall sharp increases in the concentrations of all constituents except iron and nitrate, which declined appreciably, and carbon dioxide which remained relatively unchanged.

This stage shows the compound effects of contamination from several sources. The occurrence of iron, carbon dioxide, and probably nitrate were related chiefly to continued vertical leakage from the unconfined aquifers. The decline in the concentration of iron and nitrate

since 1951 may be attributed to changes in the pumping regimen of the Naval Base wells. In 1952 wells Ph-25, 26, 27, and 28 were completed. Operation of Ph-28 has had an especially significant effect. Judging from quality-of-water data the well apparently is in the area of effective recharge from the unconfined aquifer and derives practically all of its yield from this source. Since inception of pumping it has yielded a moderately mineralized, strong alkaline-earth, bicarbonate-type water. When Ph-28 was placed in operation it intercepted much of the vertical leakage from the unconfined aquifers, thereby decreasing the quantity of recharge from this source to Ph-1 and other wells.

The increases in concentration of the other constituents during the second stage of contamination and the accompanying transition in character toward an alkaline-earth, sulfate-type water are related to contamination from ground water moving downdip and laterally in the aquifer from relatively remote sources of recharge. It has been demonstrated that the mineral content of the ground water increases markedly up the hydraulic gradient (Pl. 21), and differs somewhat in character from place to place. Thus, the moderate contamination in early 1947 reflected movement of water from relatively nearby reaches of the aquifer, probably from the vicinity of wells Ph-6, 66, and 140. The pronounced changes that began in 1950 were due to migration of water from more distant areas, possibly from the vicinity of wells Ph-85 and 87. It is significant that this trend continued despite the reduction in pumpage from the well field that also began about 1950. Evidently the progressive increase in mineral content of the water moving downdip was sufficient to offset the effects of the decline in the rate of movement resulting from the reduction in pumpage.

The erratic fluctuations in the concentration of the individual constituents and dissolved solids in well Ph-1 since 1950 (Fig. 24) reflect the intermittent changes in the pumping regimen of the well field. For example, the quality of water from Ph-1 improved during periods that wells Ph-25 and 26 were in operation because these wells intercepted some of the contaminated water moving downdip toward Ph-1. Reduction of withdrawals from wells Ph-2 and 8 had similar effects because movement of water of native quality toward well Ph-1 was facilitated. Conversely, reduction of pumpage from wells Ph-25 and 26 or increased pumpage from wells Ph-2 and 8 resulted in increased contamination in Ph-1. Operation of Ph-28 has had mixed effects. As previously noted, when well Ph-28 was being pumped the concentration of iron in Ph-1

declined appreciably, but dissolved solids and hardness increased significantly because the capture of local recharge by well Ph-28 was counter-balanced by an increase in the quantity of highly mineralized water moving downdip to well Ph-1.

Analytical data can be used to illustrate the rate of movement of ground water between wells. The graphs in Figures 25 and 26 showing the concentration of sulfate in water from wells Ph-4 and 8 are essentially similar. They show the sulfate concentration to have remained relatively constant for the first few years after the inception of analyses in 1943. Then there was a general increase in sulfate over a period of several years, and finally there was a decrease in sulfate during the later part of the record. The approximate date of occurrence of the maximum sulfate content at well Ph-4 was December 1950, and the date of occurrence at well Ph-8 was 1½ years later in May 1952. The distance, in feet, from well Ph-4 to 8 (1,100 feet) divided by the time in years required for the high sulfate content to negotiate that distance (1½ years) should give the approximate rate of movement of ground water between these two wells in feet per year.

$$\frac{1100}{1.5} = 733 \text{ feet per year}$$

$$\frac{733 \text{ feet per year}}{365 \text{ days}} = 2.0 \text{ feet per day}$$

Obviously, the rate of movement of water in the Farrington member is exceedingly slow. At this rate it would take about 18 years for water to move 2½ miles, the distance from the Schuylkill River, near Passyunk Avenue, to the center of pumping at the Naval Yard. However, because wells Ph-4 and Ph-8 lie near the steepest part of the hydraulic gradient, close to the center of pumping in the Naval Base, it is probable that even the rate of 2.0 feet per day may be too high a figure to apply to the entire area. Hence, 30 years or more may not be too conservative an estimate of the time needed for the movement of ground water from the vicinity of the Schuylkill River to the Naval Yard.

Greenwich Point trough area

In the Greenwich Point and Washington Square troughs the concentration of dissolved solids (Pl. 21) and the concentration of sulfate (Pl. 22) generally decrease downgradient, toward the major centers of pumping in distal parts of the troughs. This pattern is interrupted

within the centers of pumping by what appears to be potent contamination from local recharge in the form of vertical leakage through the overlying confining clay. The pattern is modified also by the induction of recharge of superior quality which enters the aquifer from the Delaware River through the suboutcrop area along the eastern border of the Washington Square trough.

It has previously been brought out that development of water supplies from the Farrington member began 20 years or so earlier in the Greenwich Point and Washington Square troughs than in the League Island trough. The quality of water from wells in the Greenwich Point trough now appears to be in equilibrium with the hydrodynamic environment, and future changes in quality may be expected to be slight and generally insignificant.

Long-term records of water quality are available for wells Ph-407, 143, 144, and 145 which tap the lower aquifer in and around the Publicker well field in the Greenwich Point trough. Most of the analyses are partials, however, and only the anion totals are consistently reported. There are 25 water-sample analyses for water from well Ph-407 for the period December 1949 to February 1956. Wells Ph-143, 144 and 145 were sampled sporadically, sometimes monthly, sometimes semiannually, from the summer of 1946 to 1954 for wells Ph-144 and 145, and from the latter part of 1945 to the beginning of 1950 for well Ph-143.

The water quality of well Ph-407 has been remarkably stable over the entire period of record. The water has been of the calcium-magnesium bicarbonate type, with bicarbonate averaging 63 percent, sulfate 20 percent, and chloride plus nitrate approximately 17 percent. The dissolved-solids content has varied from about 120 to 200 ppm. Iron, although reported infrequently, has been found present in significant quantities from the inception of analyses and has ranged from 3.3 ppm to 12 ppm.

Water from wells Ph-143, 144 and 145 shows different features of quality than that from well Ph-407, owing to their proximity to a source of local recharge. The dissolved-solids content of water from these wells has varied from 350 to 450 ppm during the period of record. The iron content has varied considerably, but in general it has been very high. Water from well Ph-144 shows the greatest range in iron con-

tent—from 5.8 ppm of total iron in September 1953 to 79 ppm in April 1951. In many of the analyses the amount of iron is unreported, but its presence in substantial quantities is indicated by remarks accompanying the various analyses which invariably state that in the interval between collection and analysis, iron precipitated from solution. Few of the samples were analyzed for all cations, but those that are available indicate that the alkaline-earth constitutents are in excess of the alkalies (sodium and potassium).

Unlike well Ph-407, which has had rather distinct bicarbonate waters throughout most of the period of analyses, wells Ph-143, 144 and 145 show lesser amount of bicarbonate and larger quantities of sulfate and chloride. Water from well Ph-143 (4 analyses) has been of the bicarbonate-chloride type with bicarbonate averaging about 41 percent, sulfate 24.5 percent, and chloride plus nitrate 34.5 percent. The water from well Ph-145 has been of the sulfate-chloride type throughout most of the period of record. During this interval, the percentage of the various anions changed only slightly, as bicarbonate averaged about 30 percent, sulfate 36 percent, and chloride plus nitrate 34 percent. Of the three wells, well Ph-144 has the most complete set of analyses, and water from this well shows a gradual change from a dominantly bicarbonate low-sulfate water during the early years of record to a relatively high sulfate low-bicarbonate water during the latter years of record.

Changes in the Sayreville Sand Member

As described in the subsection entitled "Native quality of water," the quality of the native ground water in the Sayreville member probably was indisguishable from that of the Farrington member. It was a moderately mineralized sodium bicarbonate-type water low in iron. Well Ph-10, at the Naval Base, is the only producing well that taps the Sayreville member in south Philadelphia. Two analyses of water from well Ph-10, one made in April 1951 and one made in February 1954, are given in Table 12. They show a moderate increase in dissolved solids accompanied by a change in character from a sodium bicarbonate water to an alkaline earth-bicarbonate water. Thus the quality of the water in the Sayreville member has depreciated in the same manner described for the first stage of contamination of the Farrington member in the Naval Base. Leakage from the unconfined aquifers is undoubtedly the

source of the contamination. The contamination probably began when pumping from the Farrington member began and was accelerated after well Ph-10 was placed in service.

The second stage of contamination noted for the Farrington member has not been a factor in the Sayreville member, and it is not likely to be a factor in the future. Subsurface geologic data given in Plate 3 indicate that there is no hydraulic continuity between the member and the highly contaminated unconfined aquifer in the updip reaches of the trough. The only other source of such contamination is leakage from the underlying Farrington member, but movement in that direction is impossible because the hydraulic head in the Sayreville member is 20 feet or so higher than that in the Farrington member (Fig. 18).

Prospects for Further Development

Availability of water appears to be the least of the problems that may interfere with further development of ground-water supplies in Philadelphia County. It is impossible to estimate the perennial yields of the various aquifers because the hydrologic environment, including both its natural and artifical factors, is too complex to permit evaluation of their potential. But is is safe to say that present utilization is only a fraction of what could be realized with optimum development.

The most promising sources of additional supplies are the unconfined aquifers where they are adjacent to and hydraulically continuous with the Delaware or Schuylkill Rivers. Only one large supply, that of the Publicker Commercial Alcohol Co., is obtained from these aquifers, but numerous similar supplies could be developed at favorable sites along the Schuylkill and Delaware Rivers. Properly located and developed wells would derive the major part of their yields from induced river recharge, thereby insuring against serious depletion of ground water in storage.

Inland from the Delaware and Schuylkill Rivers the prospects for development of large supplies from the unconfined aquifers are less favorable because the benefit of induced recharge diminishes with distance from the sources of recharge. Table II lists several wells, having reported yields of several hundred gallons per minute that tap the unconfined aquifers at distances of half-a-mile or so from either river. Therefore, even in these areas, the unconfined aquifers may be important

sources of moderate supplies. These areas, however, are remote from sources of induced recharge and heavy pumping may cause depletion of ground-water storage to the point where economic recovery of ground water is no longer feasible.

The artesian aquifers will support some additional development in south Philadelphia. This statement is based on the fact that the water level in south Philadelphia show no persistent decline. As an inspection of figures 18, 19, and 21 will show, water levels in wells Ph-20, 61, and 249, tapping the Farrington sand member of the Raritan formation, were at about the same level in 1957 that they occupied in the period 1944-47.

The perennial yield of the Farrington member in south Philadelphia cannot be determined because too many variables are involved. The hydraulic properties of the aquifer and the overlying beds differ from place to place owing to changes in thickness and composition of the beds. Even if these were constant and known, no single maximum rate of induced recharge to the aquifer could be calculated because it would vary according to pumpage from overlying aquifers. Furthermore, the artesian head in south Philadelphia is influenced by pumpage from adjacent areas in New Jersey, and this pumpage may vary considerably.

The potential value of the Sayreville member as a source of supply in south Philadelphia is uncertain because of the absence of adequate geologic and hydraulic data for the member. Only one well, Ph-10, is known to yield from the Sayreville member. Between 1946 and 1950, the period of maximum sustained withdrawal from Ph-10, the hydraulic head in the vicinity of the well was about 35 feet below mean sea level (Fig. 18), or about 65 feet above the top of the aquifer (Pl. 3). This represents a decline of about 40 feet due to pumping, but an unknown part of the decline may be attributed to withdrawals from the underlying Farrington member. According to these data the aquifer certainly will support further development in south Philadelphia, but future development in the area will have to be guided by the results of careful field studies designed to describe the occurrence and hydraulic properties of the member in south Philadelphia.

In planning additional development of the artesian aquifers care should be taken in selecting well sites in order to avoid local overdevelopment. To take advantage of the hydraulic characteristics of the artesian aquifers, wells should be located along the axis of the troughs. The

spacing of the wells would be determined by their yields, but assuming identical yields the distance between wells must increase updip to allow for the decrease in the thickness and, hence, the transmissibility of the aquifer. The thickness of the confining clay also decreases updip. These variables preclude mathematical expression of the optimum spacing of wells in a proposed well field; the most practical and efficient design must be determined empirically during the development of the well field.

The Point Breeze trough, including the area on the south bank of the Schuylkill River, is perhaps the most promising area for future development from the Farrington member. The water-bearing properties of the member in the Point Breeze trough are unknown because no wells tap it in that area. The absence of wells may in itself be ominous, but pending the availibility of negative data the aquifer in that area should be considered a promising potential source of ground water.

Quality of water will unquestionably be the principal limiting factor in the future utilization of ground water in Philadelphia County. It has been demonstrated that the quality of ground water in storage in the aquifers has deteriorated appreciably as a result of human activities. The contamination of water in storage probably will increase, rather than lessen, in the foreseeable future and will be accelerated by increased withdrawals. This forecast obtains even if the strongest measures are taken to hold the contamination at its source. For example, dumping grounds and landfills are important sources of contamination to ground water, but if these practices of waste disposal are abolished in south Philadelphia there will be no immediately discernible improvement in the quality of water, because the accumulated refuse from past years will continue to yield contaminants for many years to come.

The only possible sources of ground water of improved quality in the foreseeable future are well supplies from unconfined aquifers that yield water derived largely from induced river recharge. This will mitigate the effects of chemical contamination of the ground water in storage so long as the river water is of desirable chemical quality. However, the value of these supplies for industrial cooling which is the major category of use of ground water in Philadelphia, might be severely depreciated by changes in the temperature of the water. For example, at a given site a well tapping the unconfined aquifers might have to derive 90 percent or more of its yield from induced river recharge to obtain a

blend of suitable chemical quality. Such a ratio is not impossible to achieve, but under those conditions the temperature of the well supply would soon approach that of the river water and would show similar seasonal fluctuations. Thus the natural temperature advantage of ground water over surface water for cooling use would be sacrificed.

The future prospects of obtaining water of satisfactory quality from the artesian aquifers are even less favorable. Under present development virtually all recharge to these aquifers in Philadelpha is derived from the unconfined aquifers. Assuming no change in the distribution and rates of withdrawal, the composition of the artesian water must eventually change to that of a representative mixture from the various areas of recharge. It is impossible to synthesize the chemical composition of the resultant blend in detail because of differences in the character of local recharge. However, most supplies will ultimately yield a moderately to highly corrosive alkaline-earth sulfate water, containing 500 to 1,000 ppm or more of dissolved solids and several parts per million iron.

Additional development of the artesian aquifers will lower the artesian head, thereby increasing the rate of recharge to the aquifer. This probably will not appreciably change the terminal quality of the artesian water, but will speed the day of its realization. It should be emphasized that this development need not be concentrated in Philadelphia. Increased withdrawals from the artesian aquifer in adjacent areas of New Jersey will also effect water levels in Philadelphia.

The possibilties of improving the quality of recharge to the artesian aquifers are not favorable . The Sayreville member is not known to be directly exposed to river recharge anywhere in Philadelphia, and the Farrington member is hydraulically continuous with a surface source along only a narrow reach of the Delaware River, across the north flank of the Washington Square trough (Fig. 3). Recharge from this area is sufficient to match only a small part of current withdrawals; so, increased development must be satisfied largely by movement of water from the unconfined aquifers, which would lead to further contamination of the artesian supplies.

Contamination must, therefore, be viewed as a permanent problem in south Philadelphia. For some time to come, development of groundwater supplies undoubtedly will involve compromises of yield, physical

quality, chemical quality, or all three factors. Maximum utilization of ground water in Philadelphia will depend upon the development of techniques for use or treatment of the contaminated water that would make it competitive with city water. A discussion of these techniques is beyond the scope of this report. However, it should be emphasized that the industrial utility of most of these supplies would be reclaimed if economic methods were found for softening the water, removing the iron, and adjusting the pH for large supplies for cooling or other nonconsumptive industrial uses.

EFFECTS OF HUMAN ACTIVITIES ON THE OCCURRENCE OF GROUND WATER IN SOUTHEASTERN BUCKS COUNTY

Southeastern Bucks County has experienced tremendous growth of population and industry in the postwar years. Despite this recent approach toward urbanization the most significant hydrologic effects of human activities stem from land-use practices related to the area's long history of suburban development.

Like urban development, suburban development involves—in addition to water-supply development—a number of miscellaneosus activities not related to water use that significantly affect the hydrologic environment. Whereas occupancy of the land is paramount in an urban area, suburban development features use of the land for its agricultural and mineral value to provide the needs of the neighboring urban areas.

Changes in the Regimen

The growth of the Philadelphia urban area required tremendous quantities of sand and gravel aggregate, much of which was obtained from dredging basins in the Coastal Plain sediments of southeast Bucks County. As a result, the water-table aquifer has been physically removed in many areas and replaced by artificial lakes which by 1956 covered about 3 square miles or over 8 percent of the Coastal Plain terrane in Bucks County. (See Pl. 6.)

The artificial lakes are important hydrologic features. They interrupt the continuity of the water table and, thus, function as hydraulic boundaries to movement of ground water in the unconfined aquifers. But they are most important as storage reservoirs. As the lakes are hydraulically continuous with the water-table aquifers, they serve as sources of induced recharge to replenish the aquifers in areas of heavy withdrawal. Thus, from the viewpoint of availibility of ground water, they are desirable features.

Withdrawals from wells have influenced the regimen of the water-table aquifer locally but not areally. Until 1910 the use of ground water in southeastern Bucks County was limited chiefly to small domestic supplies obtained from wells dug to depths of a few feet below the water table. Many dug wells are still used today in rural areas beyond the reach of municipal water-supply systems.

Large-scale development of water supplies from the water-table aquifer began with the drilling of a few industrial wells in the Borough of Bristol around 1911. During the next 30 years (1911-41) numerous industrial wells were drilled in southeastern Bucks County, particularly along the Delaware River at Bristol, Cornwells Heights, and Andalusia (Pl. 6). The total withdrawal in 1941 is estimated to have been 2 mgd. The largest diversion of ground water during this period was made by Rohm and Haas, a chemical manufacturing firm southwest of Bristol.

During the war years, from 1941 to 1945, the increased demand for industrial and municipal supplies of ground water resulted in the construction of many new wells in southeastern Bucks County. In 1942 eight municipal wells were drilled for the Borough of Bristol in the Bath field, a small tract of land adjacent to the northwest side of the Borough. In 1945 five more wells were drilled in the Edgely field, about 2 miles northeast of the Bristol Borough limits along the Delaware River. During the same period five large-capacity wells were drilled to supply the new Publicker Commercial Alcohol Co. plant near Cornwells Heights. The increase in total pumpage occasioned by pumping from these wells is estimated at 3 mgd, raising the total withdrawal to 5 mgd by 1945.

Since 1950 the withdrawal of ground water from the shallow Pleistocene deposits underlying southeastern Bucks County has increased greatly, owning to the tremendous expansion of industry and the accelerated growth of population in that area. In 1952 the U. S. Steel Corp. installed three radial collector wells to supply more than 10 mgd to the newly constructed Fairless Works 4 miles south of Morrisville (Pl. 6). In the same year municipal wells were placed in operation to supply the new residential communities of Levittown and Fairless Hills. Levittown is supplied by 12 closely spaced wells bordering a small lagoon on the Delaware River at Tullytown (Pl. 6) and Fairless Hills obtains its supply from three wells on the west side of Curtis Lake (Pl. 6).

The volume and distribution of pumpage in southeastern Bucks County have remained more or less constant since 1952. The average daily withdrawals from wells totaled more than 13 mgd in 1956. Practically all of the pumpage is confined to four areas, as shown on Figure 27.

Water-level data collected during this investigation do not show a widespread decline in the water table or any continuous, progressive, local declines of water level, in spite of the pumpage from the water-table aquifer underlying southeastern Bucks County. Instead, the position of the water table has remained relatively stable and within the range of natural fluctuations, except in the immediate vicinity of discharging wells where the aquifer has been unwatered in the cone of depression caused by pumping. The dimensions of the individual cones are determined by the rate of pumping, the hydraulic properties of the aquifer, and the local hydrologic environment. The latter factor is of most importance in restricting the areal influence of pumping in southeastern Bucks County, because all major supplies are obtained from areas close to the Delaware River or one of the inland artificial lakes. These surface-water bodies supply local recharge in response to withdrawals from wells.

Thus, within the area of influence of the discharging wells, the natural regimen in the unconfined aquifer has been modified considerably by the salvage of natural discharge, which would otherwise be lost by evapo-transpiration or by seepage to surface-water bodies, and by reversal of the hydraulic gradient to induce recharge from surface-water bodies. At the present state of development these conditions occur only locally, as the natural regimen has not been measurably influenced throughout most of the area by withdrawals from wells.

Pumpage from the artesian system in southeastern Bucks County has had little influence upon the regional hydraulic head. The Farrington member is tapped by one well, Bk-629, and the Sayreville member by 15 wells. Of these, only Bk-629 is pumped consistantly at a high rate, and because it is close to the edge of the confining clay the effect of pumping is not transmitted far from the well. However, the artesian head has declined a small amount owing to withdrawals from wells in south Trenton and Bordentown, N. J. Data are not available to permit construction of a map showing the distribution of artesian pressure, but the reduction in head has been sufficient to reverse the natural hydraulic relationships, as the general slope of the hydraulic gradient is downdip, or eastward—counter to the direction of the natural gradient. Thus, natural discharge from the artesian system has ceased, and the artesian aquifers underlying southeastern Bucks County are recharged by water from the overlying unconfined aquifers.

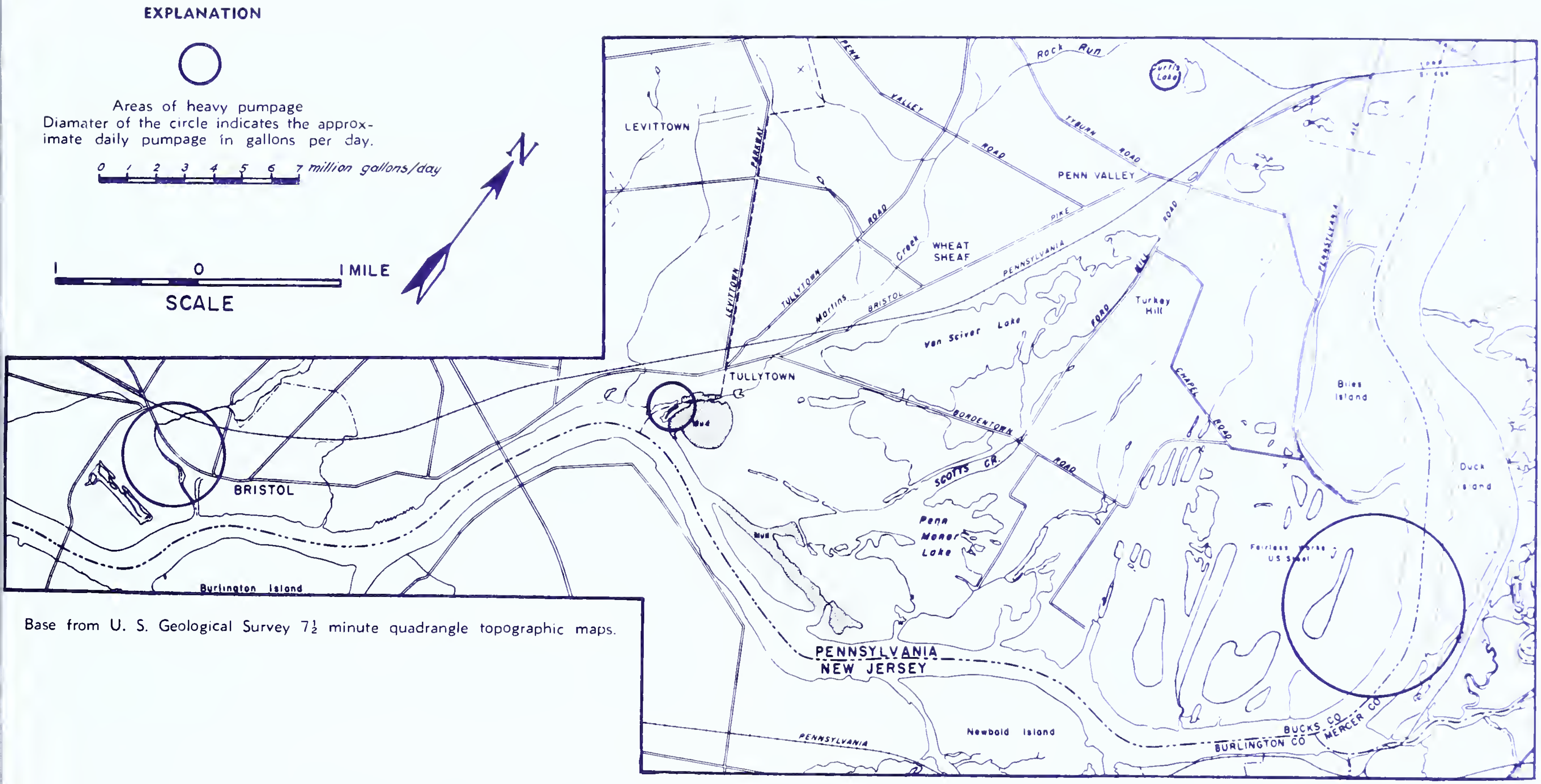


Figure 27.
Map of southeastern Bucks County showing the distribution of pumpage in 1956.

Changes in the Quality of Ground Water

Ground water in southeastern Bucks County has not experienced the severe contamination noted in south Philadelphia. Human activities have resulted in some contamination, but most supplies are of satisfactory quality for most uses with only minimal treatment.

Analyses of water from 47 wells that tap Coastal Plain aquifers in southeast Bucks County are given in Table 12. The water commonly is slightly to moderately mineralized, soft to moderately hard, and moderately acidic in reaction. Dissolved solids range from 45 to 716 ppm, and are less than 160 ppm in water from 27 of the 47 wells. The alkaline earths are the principal catons in all supplies; sulfate is the chief anion and bicarbonate, secondary. (Slight to moderate contamination of the native water is demonstrated by the dissolved-solids content, and in the concentrations of the principal anions and cations in solution.) The most obvious contaminants are nitrate and iron, both of which were virtually absent from the native waters. The recommended maximum concentration of nitrate nitrogen in drinking water for infants is 10 to 20 ppm (California State Water Pollution Control Board, 1952, p. 301). Nitrate occurs in concentrations exceeding 10 ppm in only 10 wells. Iron is the only constituent that occurs commonly in concentrations exceeding the recommended threshold concentration for drinking-water supplies and industrial cooling in Tables 2 and 3. It does not occur commonly in concentrations greater than 1 or 2 ppm so it is not a serious treatment problem in most supplies. However, its importance as a contaminant is emphasized by the recent history of the Fairless Works well supply, the largest in Bucks County, which was abandoned in 1958 owing to an intolerable concentration of iron.

Changes in the quality of water stem from several causes, the effects of which are superimposed in most areas. Precise cause and effect relationships are difficult to establish, but the probable primary sources of contamination are discussed in the following paragraphs.

All ground-water supplies show some change in quality as a result of chemical reactions in the parts of the aquifers that have been unwatered from wells. The essential feature of this kind of contamination is that it operates without benefit of chemical additions from human activities. Because it is triggered by pumping alone it cannot be controlled and must be accepted as an inevitable byproduct of utilization. The decline in water-level around a pumped well exposes to various

chemical reactions—including oxidation, hydration, carbonation, and biologic activity—minerals that through the geologic past have been in chemical equilibrium with a ground-water environment. Some of the products of these reactions are taken into solution and transported to the water table by downward-percolating recharge.

Iron is the most conspicuous product of these reactions, but other constituents are also involved. Pyrite reacts with water and oxygen to form soluble salts of iron and sulfuric acid that, in turn, react with other minerals and release additional soluble products. The net result is increased concentratons of iron and other constituents, notably the alkaline earths and sulfate.

A fragmentary history of the change in quality is evident from the analyses of water from wells Bk-531, 532, and 533, which are situated in the well field serving the Borough of Bristol, Pa. Samples collected in 1942, before the wells were placed in service, contained virtually no iron and were low in hardness and dissolved solids. After several years of pumping iron increased to as much as 5 ppm and hardness and dissolved solids increased appreciably. Analyses for water from wells Bk-651 and 652 (Table 12), representative of the ground-water supply for the Fairless Works of U. S. Steel, at Morrisville, Pa., show concentrations of iron ranging from 1.8 to 5.4 ppm for 2 samples collected in 1956. The company reports also that the concentration of iron has exceeded 15 ppm at times and for this reason the well supply was abandoned in early 1958. Such high concentrations of iron suggest that another source might be contributing iron to the water table in the vicinity of the wells. The most likely sources, of such contamination are landfill operations. The landfills may contain ferruginous material that is leached by rainfall infiltrating to the ground-water body.

The character of the contamination is controlled by the kinds of mineral material that occupy the newly unwatered zone of the aquifers. The mineral content of the water from some wells increases as the wells are pumped, but the iron content may not increase in proportion to the other changes, evidently because iron-bearing minerals are not abundant within the area of influence of the well. Analyses of water from wells Bk-479, 595, and 629 typify these conditions. These changes are relatively innocuous and may pass unnoticed in most supplies, with the possible exception of those in which hardness is a highly critical factor and is closely observed and controlled.

Nitrates are derived from leakage from sanitary disposal systems and from leaching of chemical and organic fertilizers. The latter is the probable source of the larger concentrations of nitrate—those that exceed about 15 ppm. Bucks County has long been an important supplier of truck farm produce to neighboring urban areas. Successive applications of fertilizer to the agricultural plots have contributed considerable amounts of nitrate to recharge water. Other soil conditioners have also added soluble constituents to the recharge areas—for example, calcium and bicarbonate leached from agricultural lime. Furthermore, the biologic activity promoted by these practices has accelerated the decomposition of minerals in the soil thereby producing more material for solution by recharging waters. As a result, ground water in agricultural areas commonly is moderately mineralized and is characterized by relatively high concentrations of nitrate. Analyses of water from wells Bk-636, 639, 640, 641, 642, 644, and 645, all of which are on truck farms, typifying these conditions. The concentration of nitrate in water from these wells ranges from 5.8 to 107 ppm. Dissolved solids range from 77 to 716 ppm and include the most mineralized samples collected in southeastern Bucks County. Iron does not occur in significant concentrations because withdrawals from the wells are so slight that for practical purposes there has been no unwatering of the aquifer to expose the iron-bearing minerals to solution.

The quality of ground water in southeastern Bucks County is influenced also by induced recharge from surface sources. Leggette and Brashears (1954) described changes in hardness and temperature in wells Bk-597 and 601 (during a 13-day pumping test) as a result of recharge from an adjacent lagoon which is open to the Delaware River. Such relationships are not observed in the data from most well supplies, however, because there is so little contrast between the quality of the surface and ground waters, and the differences tend to diminish owing to changes in the quality of the recharge while it is enroute to the well. As pointed out previously, all major supplies are located near a surface source of recharge, and the importance of induced recharge in maintaining the quality of the ground water should be emphasized. Most of these supplies are in areas of local urban development, but none have shown severe contamination from urban sources—probably because their yields are derived largely from induced infiltration.

Analyses of water from wells Bk-551 and 620 provide the only evidence of direct contamination from industrial activities in southeast Bucks County. When sampled in 1946 well Bk-551 yielded a mildly contaminated water which probably reflected the effects of both agricultural practices and chemical reaction in the unwatered zone. By 1956 the dissolved-solids content tripled, including an eightfold increase in chloride. This can be attributed only to industrial brines, probably wastes or leakage from the ice manufacturing plant which operates the well.

Well Bk-620 has yielded a moderately mineralized alkaline-earth sulfate-type water. Contamination is especially evident in the high iron content which was 38 ppm in the sample collected in September 1953. Drainage from coal storage piles about 2,000 feet north of the well is the probable source of the iron. An interesting feature of the September 1953 sample was the adjustment of pH and the precipitation of iron that occurred while the sample was in storage. At the time of collection the pH was 6.2 and the sample was noted to be clear. Twenty-four hours later the pH was 4.3, and the sample was clouded with red precipitate. Evidently, when the sample was collected it contained ferrous ions in solution; the aeration of the sample during and immediately after the collection resulted in oxidation and the precipitation of ferric hydroxide, $Fe(OH)_3$ and a consequent decrease in pH owing to the removal of OH^- ions from solution.

The Future of Ground-water Development in Bucks County

Prospects are favorable for the future availability of ground water in southeastern Bucks County. The water-table aquifers have high permeabilities and are hydraulically continuous with the Delaware River and the inland artificial lakes which, for practical purposes, are inexhaustible sources of recharge. Properly located and constructed wells will derive practically all of their water from induced recharge from these sources and will, thus, be assured of large perennial yields without drastic decline in ground-water levels. If the water levels in the artificial lakes decline appreciably in response to pumping, the condition could be mitigated by removing or lowering the dams which now isolate the lakes from the Delaware River, thereby converting them to tidal basins.

The artesian aquifers are promising potential sources of moderate supplies in southeastern Bucks County. Geologic data for the Sayreville member, summarized in Figure 5 and Plates 3 and 13, show that the member is continuous beneath much of the Coastal Plain. Few wells tap the member, and its water-yielding properties are not known in detail, but available well data indicate that reliable yields of 100 to 400 gpm or more can be obtained from most sites that have been tested. If these hydraulic characteristics persist throughout the member—and there are no data to indicate otherwise—the Sayreville member is an important and virtually untapped source of water supply. The Farrington member is not as areally extensive as the Sayreville member in southeastern Bucks County (Pls. 4, 8, and 10), but otherwise the same conditions apply, and it ranks as an important potential local source of moderate quantities of ground-water.

Future development of water supplies from the artesian aquifers should be guided by the geologic and hydrologic relationships shown in Plates 5 through 19 and Figures 3-5. Wells should be located near the Delaware River or other surface-water bodies wherever these surface-water bodies can act as a source of induced recharge to the artesian aquifer. Where the confining beds are relatively thick and uninterrupted, wells should be located so as to penetrate the maximum thickness of the underlying aquifers—to insure maximum yield and minimum drawdown. Under these latter conditions well-field development should be concentrated along the axes of the troughs of deposition, and the spacing of wells should be determined by pumping tests in order to prevent excessive drawdowns due to interference between wells.

The quality of future ground-water supplies is open to question. There is every reason to believe that urban development of southeastern Bucks County will have the same deleterious effect on the quality of water as has been noted in the Philadelphia area. Presumably, sewers will leak, industrial wastes will enter the aquifers, and other miscellaneous activities associated with land occupancy will contribute to contamination. Such contamination will seriously prejudice the utility of wells that yield water from ground-water storage, but it will be diluted in the discharge of wells that derive most of their yields by induced recharge from surface-water sources. Thus, from the standpoint of quality and quantity of ground water, the most favorable areas for future development are those that lie adjacent to the Delaware River or the artificial lakes.

Reclamation of the artificial lakes poses the most serious threat to the quantity and quality of ground water in southeastern Bucks County. As urbanization of the area proceeds, the combination of high land values and the need of convenient dump sites may inspire reclamation of the lakes by means of landfill projects. Such practices will have drastic consequences on the quality and availability of ground water in areas distant from the Delaware River. If they are permitted, major withdrawals will ultimately be restricted to those areas marginal to the Delaware River.

In summary, it is not possible to compute the potential ground-water yield in southeastern Bucks County, but the availability of ground-water supplies is probably adequate to meet all anticipated future needs of the area—provided that future development is based upon careful planning to insure against local overdevelopment and to protect the aquifers from severe contamination.

RECORDS OF WELLS

Records of 679 wells in the Coastal Plains area of southeastern Pennsylvania are contained in Table 11. The wells in Philadelphia County are listed first, followed by those in southeastern Bucks County. The location of each well is shown on the well-location maps (Pls. 1 and 2) by means of the well-identification number that appears along the left margin of the table. The county prefix is not shown either in the table or on the maps where it is obvious.

All of the symbols used in the table are explained in the heading, and footnotes have been used where necessary to complete the information given. If a well is screened in two or more water-bearing zones separated by a confining bed the thickness of each aquifer is shown. (See Ph-124.) If, on the other hand, the well is screened in an aquifer composed of more than one water-bearing zone and the aquifers are hydraulically continuous, the thickness of the combined interval is given. (See Ph-36.) Furthermore, in the water-level column, *reported* water level can be differentiated from *measured* water levels by the fact that the day, month, and year are given for each measured water-level (see Ph-20), whereas the year or month and year have been recorded for reported water levels (see Ph-22 and Ph-24).

CHEMICAL ANALYSES

A large number of samples of ground water were collected during the course of this investigation from wells screened in the Coastal Plain sediments. These samples were analyzed by the U. S. Geological Survey, Branch of Quality of Water, in Philadelphia, Pa., and the results are shown in Table 12. A few selected analyses from sources other than the U. S. Geological Survey have been included.

The table of chemical analyses is separated into two parts: the first part lists the wells in Philadelphia County and the second part lists the wells in Bucks County. Within each part the analyses are arranged sequentially for each well and numerically according to the well-identification number. Thus, information about the source of each sample analyzed can be obtained by noting the well-identification number and referring to the table of well records (Table 11).

WELL AND BORING LOGS

A considerable amount of geologic information used in this report was obtained from a study of drill cuttings of wells and borings and a study of logs of wells reported by drillers. From a miscroscopic examination of the drill cuttings, sample logs were prepared, the strata penetrated were identified, and the results of these studies were put in Table 13. The logs of wells and borings in Philadelpha County are presented first followed by those in Bucks County.

The logs obtained from drillers are interpreted in Tables 14 and 15. The drillers' descriptions of the materials penetrated have been retained for purposes of authenticity. Although some of the terms used are not strictly geological such as "sharp" gravel, their meaning can be readily understood in most instances.

The interpretation of some of the logs, however, is fairly difficult because the information given is too brief or incongruous to be evaluated properly. A description such as "clay and boulders" is particularly misleading. Where more than one geologic unit appears to be included in a poorly described interval, a footnote has been added for clarity.

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TABLE 11.—RECORD OF WELLS IN COASTAL PLAINS AREA OF SOUTHEASTERN PENNSYLVANIA

Depth of well: f, finished (casing and screen); p, penetrated.

Aquifer name: Qcm, Cape May formation; Kro, Old Bridge sand member; Krs, Sayreville sand member; Krf, Farrington sand member; pK, pre-Cretaceous rocks.

Use: A, air conditioning; D, domestic; I, industrial; Irr, irrigating; PS, public supply; R, rural; T, testing; U, unused; X, destroyed.

Chemical analysis: C, complete; P, partial.

Well No.	Location no.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer		Water level		Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
									Formation	Thickness (feet)	Depth below land surface (feet)	Date of measurement				
PHILADELPHIA COUNTY																
1	K23a-7443	U. S. Naval Base	Layne-New York	1940	11	12	238 p 232 f	207	Krf	70	19	5-40	730	12	PS	C
2	K23a-7542	do.	do.	1940	11	12	243 p 232 f	207	Krf	60	18	7-40	730	13	PS	C
3	K23a-7540	do.	Harmon Well	1941	12	12	268 f	238	Krf	60	30	5-41	860	48	PS	C
4	K23a-7539	do.	do.	1941	11	12	267 f	237	Krf	60	25	2-41	800	30	PS	C
5	K23a-7634	do.	Layne-New York	1942	15	12	203 p 182 f	148	Krf	44	33	4-21-42	730	14	U	C

6	K23a-7135	do.	do.	1942	10	12	190 p 171 f	138	Krf	33	33	6-20-42	720	16	PS	C
7	K23a-7651	do.	do.	1943	12	12	228 p 204 f	189	Krf	17	32	1-23-43	710	6	PS	C
8	K23a-7739	do.	do.	1944	12	12	254 p 230 f	200	Krf	57	51	12-4-44	740	24	PS	C
9	K23a-7231	do	do.	1942	10	8	140 p	......	....	....	....	....	......	....	T	....
10	K23a-7443	do.	do.	1945	12	16	146 p 140 f	133	Krs	10	34	8-27-45	350	6	PS	C
11	K23a-7240	do.	do.	1944	10	8	237 p 104 f	......	Krs	43	31	9-44	......	....	T	....
12	K23a-7241	U. S. Naval Base	Layne-New York	1944	10	8	110 p	......	Krs	27	27	11-15-44	......	13	T	....
13	K23a 7440	do.	do.	1944	12	8	73 p	54	Qcm	31	26	11-25-44	100	....	T	C
14	K23a-7342	do.	do.	1945	11	3	91 p	46	Qcm	27	30	7-26-45	......	....	T	....
15	K23a-7542	do.	do.	1945	12	3	82 p	59	Kro	18	31	9-8-45	......	....	T	C
16	K23a-7340	do.	do.	1945	11	3	84 p	52	Qcm	21	29	9-12-45	......	....	T	C
17	K23a-7144	do.	do.	1945	11	3	73 p	43	Qcm	27	4	9-18-45	......	....	T	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location no.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
18	K23a-7144	do.	Rulon	1946	13	8	218 p	218	Krf	60	....	....	......	....	T	....
19	K23a-7743	do.	do.	1946	10	6	274 p 252 f	252	Krf	63	46	4-2-46	......	....	T	....
20	K23a-7737	do.	do.	1946	13	8	266 p 244 f	244	Krf	87	23	5-14-46	......	....	T	....
22	K23a-7928	U. S. Naval Ammo Depot	Artesian Drlg.	1944	10	10	127 p 103 f	66	Qcm	8	19	7-44	......	....	X	....
23	K23a-7539	U. S. Naval Base	Conlan	1900	10	10	600 p	260	Pk	....	....	....	25	....	X	....
24	K23a-7539	do.	Harper	1900	10	10	906 p	260	Pk	....	28	1899	50	....	X	....
25	K23a-7747	do.	Schultes & Sons	1953	11	12	229 f	199	Krf	45	41	1-5-53	1,200	12	PS	C
26	K23a-7240	do.	do.	1952	10	12	208 f	176	Krf	60	45	9-5-52	830	18	PS	C
27	K23a-7843	do.	do.	1952	11	12	245 f	214	Krf	62	47	10-24-52	640	23	PS	....

28	K23a-7141	do.	do.	1952	10	12	250 p 206 f	176	Krf	69	34	10-6-52	1,000	24	PS	C
29	K23a-7613	Pa. Railroad Co.	Harper	1918	10	8	49 f	41	Qcm	30	8	1918	50	....	X	....
30	K23a-8311	Phila. Airport	Layne-New York	1938	12	10	198 p 125 f	105	Krs	44	12	8-38	870	36	U	....
31	K23a-5921	WFIL Station	Ridpath & Potter	1938	5	6	71 f	62	Qcm	40	9	1-5-38	50	50	X	....
32	K23a-5326	Phila. Gas Works	....	1915	28	6	96 p	......	Pk	....	35	4-20-53	120	....	U	....
33	K23a-6726	Pa. Railroad Co.	Ridpath & Potter	1940	11	6	100 p	74	Krf	33	6	12-26-40	170	6	X	....
34	K23a-7127	do.	Harper	1906	8	6	154 f	100	Pk	46	20	1906	6	....	U	....
35	K23a-6319	Gulf Oil Corp.	Sprague & Henwood	1936	17	2	106 p	......	Qcm-Krf	30	....	....	......	....	X	....
36	K23a-6621	do.	do.	1936	21	2	81 p	......	Qcm-Krf	68	....	....	......	....	X	....
37	K23a-6721	do.	Rulon	1936	17	6	90 p	......	Qcm-Krf	20	....	....	......	....	X	....
38	K23a-6420	do.	Sprague & Henwood	1936	16	2	90 p	......	Qcm-Krf	15	....	....	......	....	X	....
39	K23a-6619	do.	do.	1936	17	2	73 p	......	Qcm-Krf	11	....	....	......	....	X	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location no.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer		Water level		Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
									Formation	Thickness (feet)	Depth below land surface (feet)	Date of measurement				
40	K23a-6321	Gulf Oil Corp.	Rulon	1936	17	6	79 p	......	Qcm-Krf	36	....	....	......	....	X	....
41	K23a-6522	do.	Sprague & Henwood	1936	19	2	70 p	......	Qcm-Krf	26	....	....	......	....	X	....
42	K23a-6725	do.	Rulon	1936	16	6	108 p	88	Pk	....	....	....	100	....	X	....
43	K23a-6725	do.	do.	1946	17	6	82 f	72	Krf	25	18	2-26-47	310	20	I	P
44	K23a-6725	do.	do.	1946	17	6	82 f	72	Krf	25	14	3-11-46	420	42	I	C
45	K23a-6343	S. Daniel Cox	....	1935	8	....	36 f	......	Qcm	26	36	1935	......	....	D	C
46	K23a-6231	H. Brooke	Harper	1914	19	8	123 f	72	Krf	30	25	1914	70	....	X	....
47	K23a-4741	Abbotts Dairies	Harper	1906	28	6	386 f	129	Pk	....	37	1906	40	....	X	....
48	K23a-4741	do.	Artesian Drlg.	1925	28	10	102 f	......	Krf	13	27	1925	220	....	I	C

49	K23a-4741	do.	Harper	1929	25	8	587 f	160	Pk	....	27	1929	200	....	U	C
50	K23a-4741	do.	Layne-New York	1944	27	10	117 p 98 f	83	Krf	13	34	7-28-44	110	3	I	C
51	K23a-5432	Jardin Brick Co.	Quinn & Herron	1906	30	6	215 f	96	Pk	....	....	....	70	....	X	....
52	K23a-5432	do.	do.	1908	30	6	240 f	90	Pk	....	....	....	60	....	X	....
53	K23a-5432	do.	do.	1923	30	6	250 f	96	Pk	....	....	....	50	....	X	....
54	K23a-4734	American Ice Co.	Artesian Drlg.	1916	35	6	90 f	70	Qcm	....	20	....	50	....	X	....
55	K23a-4527	Cooklyn Dairies	Rulon	1946	33	8	232 p 68 f	......	....	....	....	....	......	....	X	....
56	K23a-4533	Fleisher Industrial Center	Harper	1919	37	10	1,405 f	85	Pk	....	27	1919	10	....	X	....
57	K23a-4533	do.	do.	1919	37	8	580 f	83	Pk	....	20	1919	60	....	X	....
58	K23a-4533	do.	do.	1920	37	8	490 f	80	Pk	....	22	1920	20	....	X	....
59	K23a-4327	Puritan Looms.	Artesian Drlg.	1934	35	12	58 f	58	Qcm	70	19	1934	180	....	U	....
60	K23a-4327	Coco-Cola Bottling Co.	Ridpath & Potter	1936	35	8	383 f	50	Pk	....	24	5-27-36	120	2	I	C

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
TABLE 11.—RECORD OF WELLS, Continued																
61	K23a-6838	League Island Park	Artesian Drlg.	1919	15	6	199 p	......	Krf	64	31	11-19-43	......	....	U	....
62	K23a-6937	do.	do.	1919	8	6	185 p	......	Krf	64	....	....	100	....	PS	P
63	K23a-6738	do.	do.	1919	8	6	......	......	Krf	64	37	9-14-54	100	....	PS	....
64	K23a-6837	League Island Park	Artesian Drlg.	1919	15	6	184 p	......	Krf	62	....	....	100	....	PS	....
65	K23a-6938	do.	Ridpath & Potter	1952	8	6	71 f	71	Qcm	50	18	5-26-52	50	4	I	....
66	K23a-6026	Printz Degreasing Co.	Harper	1903	15	6	253 f	106	Pk	....	14	1903	60	....	X	P
67	K23a-6328	Atlantic Refining Co.	Artesian Drlg.	1915	28	6	74 f	......	Qcm-Kro	63	35	10-2-53	100	....	U	....
68	K23a-5530	do.	....	....	29	16	100 p 97 f	77	Krf	29	....	....	......	....	X	....
69	K23a-5628	do.	....	1937	31	16	104 p	81	Krf	27	20	8-17-37	300	20	U	....

70	K23a-5529	do.	....	1920	32	24	85 f	62	Krf	29	....	....	......	....	X	....
71	K23a-5926	do.	....	1920	15	....	......	......	....	....	....	....	......	....	X	....
72	K23a-5824	do.	....	1920	20	....	......	......	....	....	....	....	......	....	X	....
73	K23a-5024	do.	....	1921	16	12	607 p 88 f	88	Qcm	18	21	8-15-52	200	9	I	P
74	K23a-5223	do.	....	1921	11	16	503 p 83 f	83	Pk	....	....	....	......	....	X	....
75	K23a-5024	do.	....	....	18	....	101 p	......	Qcm	27	....	....	......	....	X	....
76	K23a-5124	do.	....	1904	30	6	95 f	......	Qcm	27	....	....	320	....	X	P
77	K23a-5223	do.	....	1920	17	18	104 f	......	Pk	....	19	10-2-53	......	....	U	....
78	K23a-5225	do.	....	1920	15	....	......	......	....	....	....	....	......	....	X	....
79	K23a-5227	do.	....	1920	20	....	......	......	....	....	....	....	......	....	X	....
80	K23a-5430	do.	Artesian Drlg.	1930	33	16	150 p	95	Krf	12	36	10-2-53	30	....	U	....
81	K23a-5430	Atlantic Refining Co.	Layne-New York	1925	30	26	90 f	56	Qcm Krf	7	19	8-17-37	300	20	X	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
82	K23a-5223	Atlantic Refining Co., Inc.	....	1933	12	60	68 p	68	Qcm	30	....	....	200	7	X	....
83	K23a-5125	do.	Ridpath & Potter	1946	20	10	77 p	60	Krf	27	17	2-15-46	610	44	I	C
84	K23a-5024	do.	do.	1948	25	12	78 f	58	Qcm	27	23	7-30-48	300	30	I	P
85	K23a-6438	U. S. Naval Hospital	Layne-New York	1942	14	10	147 p 132 f	107	Krf	44	22	8-7-42	440	18	PS	C
86	K23a-6336	do.	do.	1942	14	10	151 p 142 f	117	Krf	47	24	9-11-42	560	28	PS	....
87	K23a-5736	Girard Estate	Harper	1912	18	8	612 f	153	Pk	....	33	11-18-43	120	....	U	P
88	K23a-4228	Mirto Cullet Supply Co.	Artesian Drlg.	1933	33	6	66 f	66	Qcm	65	32	1933	40	....	I	C
89	K23a-4326	Millar Bros. & Co.	Ridpath & Potter	1951	20	8	230 f	54	Pk	....	27	4-24-51	80	....	U	....
90	K23a-4324	Zuckerman & Honickman	do.	1904	16	8	300 f	18	Qcm	18	13	1904	80	11	U	P

91	K23a-4231	Henry Bower Chemical Mfg Co.	Rulon	1930	30	10	130 f	79	Krf	11	34	5-20-33	180	7	X	....
92	K23a-4231	do.	Artesian Drlg.	1934	31	12	100 p 80 f	80	Krf	11	33	1934	110	....	X	P
93	K23a-4231	do.	do.	1946	30	8	100 f	80	Krf	11	20	1-46	50	....	I	C
94	K23a-4030	Hyman Brodsky & Son Corp.	do.	1929	13	8	65 p	65	Krf	25	11	1929	300	....	X	....
95	K23a-4131	Gold Crest Dairies	Ridpath & Potter	1938	20	8	490 f	21	Pk	....	19	5-19-38	10	<1	U	....
96	K23a-4431	Earl Theater	Layne-New York	1940	40	8	78 p 51 f	41	Qcm	17	34	8-3-40	110	16	A	....
97	K23a-4234	American Ice Co.	Harper	1902	39	8	487 f	72	Pk	....	40	1902	70	....	X	....
98	K23a-4238	Merchant & Evans Co.	....	1905	39	8	54 f	......	Qcm	69	40	7-52	20	....	A	C
99	K23a-4240	I. J Horstmann & Sons	Doyle	1922	37	48	60 f	60	Qcm	72	32	1953	250	....	I	....
100	K23a-4241	do.	Ridpath & Potter	1938	37	10	67 f	52	Qcm	50	30	10-25-38	110	6	I	....
101	K23a-4234	Pa. Range & Boiler Co.	Rulon	1940	35	6	78 p	......	Pk	....	....	....	10	....	X	....
102	K23a-4341	American Ice Co.	Harper	1904	35	6	120 f	90	Krf	17	26	1904	180	....	X	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
103	K23a-4341	American Ice Co.	Harper	1904	35	6	59 f	49	Qcm	50	24	1904	30	....	X	....
104	K23a-4341	do.	do.	1906	35	8	78 f	58	Qcm	65	27	1906	100	....	X	....
105	K23a-4341	do.	Artesian Drlg.	1916	35	10	146 f	96	Pk	....	33	1916	200	...	X	....
106	K23a-4025	Phila. Abattoir Co.	Rulon	1931	20	16	31 f	......	Pk	....	10	5-8-53	60	....	U	....
107	K23a-4834	Breeze Theater	....	....	32	8	70 f	60	Qcm	57	41	8-17-50	50	....	U	....
108	K23a-5242	Broadway Theater	Layne-New York	1937	25	8	127 p 100 f	68	Qcm	80	41	7-1-37	200	6	A	C
109	K23a-4024	Oscar Mayer & Co.	Harper	1914	10	6	47 f	11	Pk	....	20	1914	50	....	X	....
110	K23a-4024	do.	do.	1919	10	8	40 f	40	Pk	....	18	1919	40	....	X	....
111	K23a-4024	do.	do.	1919	10	8	102 f	38	Pk	....	18	1919	......	....	X	....

112	K23a-3934	U. S Naval Home	Layne-New York	1941	38	8	69 p	-----	Qcm Pk	33	40	----	------	1941	X	....	
113	K23a-3836	U. S. Naval Home	Layne-New York	1941	38	8	71 p	-----	Qcm Pk	24	39	1941	------	----	X	----	
114	K23a-3934	do.	do.	1941	30	8	56 p	-----	Qcm Pk	26	39	1941	------	----	X	----	
115	K23a-3634	Standard Ice Co.	Harper	1906	10	8	310 f	50	Pk	----	6	1906	1	----	X	----	
116	K23a-3634	do.	do.	1906	10	8	128 f	14	Pk	----	10	1906	4	----	X	----	
117	K23a-3634	do.	do.	1906	10	8	409 f	-----	Pk	----	10	1906	20	----	X	----	
118	K23a-3634	do.	do.	1906	10	8	280 f	42	Pk	----	6	1906	100	----	X	----	
119	K23a-3338	Rittenhouse Hotel	do.	1917	32	8	620 f	100	Pk	----	25	1917	60	----	X	----	
120	K23a-3635	Slater System Inc.	Ridpath & Potter	1946	15	8	366 f	33	Pk	----	25	11-20-46	40	----	U	C	
121	K23a-3943	Royal Theater	Rulon	1937	40	8	58 f	-----	Qcm	40	----	----------	------	----	X	----	
122	K23a-3743	Phila. Wireless Tech. Institute	Ridpath & Potter	1947	36	6	285 f	101	Pk	----	48	5-26-47	20	<1	A	C	
123	K23a-3445	Lafayette Hotel	Harper	1937	25	8	484 f	-----	Pk	----	----	----------	60	----	X	----	135

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
124	K23a-5134	President Theater	Ridpath & Potter	1936	31	8	86 f	65	Qcm Krf	50 4	39	6-22-36	90	3	A	P
125	K23a-4643	Southern Theater	do.	1937	25	8	101 f	80	Krf	10	43	4-3-37	60	2	U	....
126	K23a-5348	Grand Theater	Artesian Drlg.	1936	20	8	108 f	......	Krf	40	....	....	250	....	A	P
127	K23a-5149	I. Frank & Sons	Ridpath & Potter	1936	22	8	95 f	72	Krf	18	42	3-3-36	100	4	I	C
128	K23a-6054	Twin Packing Co.	Schultes & Sons	1946	12	8	180 f	140	Krf	39	45	11-5-46	1,200	20	I	C
129	K23a-4747	General Baking Co.	Harper	1904	25	10	270 f	188	Krf	18	25	1904	100	....	I	C
130	K23a-5657	Quaker City Cold Storage	Ridpath & Potter	1926	11	10	169 f	139	Krf	35	18	8-11-26	550	28	X	....
131	K23a-4746	Moyamensing Prison	....	1933	25	6	608 f	......	Pk	....	....	....	10	....	PS	....
132	K23a-4647	Bell's Beverages	Artesian Drlg.	1933	25	8	81 f	......	Krf	18	....	....	30	....	U	C

133	K23a-4648	Phila. Ice Cream Co.	Artesian Drlg.	1935	25	8	80 f	80	Krf	19	39	1935	120	....	X	C
134	K23a-4943	Savoia Theater	Layne-New York	1937	25	8	86 f	66	Krf	17	32	6-11-37	250	25	A	C
135	K23a-3543	Racquet Club	....	1907	45	8	500 f	......	Pk	....	35	4-27-53	50	....	U	....
136	K23a-3543	do.	....	1907	45	8	500 f	......	Pk	....	....	....	50	....	U	....
137	K23a-7047	Pa. Railroad Co.	Layne-New York	1919	8	6	169 f	......	Krf	29	22	4-22-36	210	8	X	....
138	K23a-7047	do.	do.	1919	8	6	187 f	......	Krf	24	24	4-22-36	290	11	U	....
139	K23a-7047	do.	do.	1940	20	8	186 p 179 f	158	Krf	29	29	1-12-40	300	13	X	C
140	K23a-7047	do.	do.	1941	20	8	193 p 183 f	165	Krf	24	27	5-22-41	480	18	X	C
141	K23a-5854	Liquid Carbonic Corp.	Ridpath & Potter	1950	10	8	185 p 73 f	55	Qcm	53	38	7-22-50	60	65	I	....
142	K23a-5854	do.	....	....	13	....	......	......	....	....	....	....	......	....	I	....
143	K23a-6056	General Cold Storage	Layne-NewYork	1928	10	10	185 p 159 f	143	Krf	27	29	8-16-28	630	12	U	C
144	K23a-6156	do.	do.	1928	11	10	185 p 161 f	135	Krf	32	23	7-25-28	770	28	I	C

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
145	K23a-6056	General Cold Storage	Layne-New York	1946	9	10	139 f	124	Krf	27	49	7-18-46	500	18	I	C
146	K23a-5953	Best Markets	Shultes & Sons	1943	13	8	171 f	140	Krf	45	62	11-43	400	....	I	C
147	K23a-5953	Delaware River Jute Mills	do.	1943	12	12	172 f	146	Krf	45	49	8-13-43	500	....	U	P
148	K23a-5954	do.	do.	1939	12	12	168 f	137	Krf	46	48	5-39	800	10	U	P
149	K23a-6252	Pa. Railroad Co.	Harper	1910	9	6	149 f	138	Krf	35	7	1910	10	....	X	....
150	K23a-7255	do.	Ridpath & Potter	1929	20	12	185 f	172	Krf	61	23	1-21-29	750	17	X	....
151	K23a-7255	do.	do.	1929	20	8	89 f	64	Qcm	76	23	9-23-29	150	....	U	....
152	K23a-7255	do.	Layne-New York	1936	10	16	237 p 199 f	179	Krf	61	26	4-6-36	730	17	D	C
153	K23a-6258	do.	Ridpath & Potter	1941	10	8	200 p 149 f	141	Krf	48	38	8-16-41	10	<1	X	....

154	K23a-5152	Joseph Giorgio	Artesian Drlg.	1932	17	8	76 f	73	Krs	10	19	1932	100	2	X	....
155	K23a-5152	do.	....	1946	17	....	......	......	....	....	....	....	......	....	I	....
156	K23a-5152	S. Phila. Beef Co.	Robbins	1938	17	8	112 f	......	Krf	23	30	1944	250	....	I	....
157	K23a-4448	American Ice Co.	Harper	1909	27	8	65 f	55	Krf	10	25	1909	100	....	X	....
158	K23a-4448	do.	do.	1909	27	8	65 f	55	Krf	10	25	1909	100	....	X	....
159	K23a-4346	do.	Artesian Drlg.	1930	27	16	81 f	81	Krf	10	34	1930	300	....	I	P
160	K23a-4446	do.	do.	1931	27	16	82 f	82	Krf	10	34	1931	250	....	I	P
161	K23a-4346	Penn Paper & Stock Co.	Harper	1902	27	8	263 f	37	Pk	....	....	....	10	....	X	....
162	K23a-4345	Wyeth Inc.	Artesian Drlg.	1935	35	12	73 f	......	Krf	10	47	10-13-53	150	....	U	....
163	K23a-4345	do.	Rulon	1943	28	8	50 f	45	Qcm	43	....	....	150	....	A,I	C
164	K23a-4345	F. H. Levey Co.	Artesian Drlg.	1930	28	12	85 f	65	Krf	10	22	1930	210	18	I	C
165	K23a-4245	John Williams	Harper	1907	28	6	350 f	110	Pk	....	....	....	20	....	U	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
166	K23a-4851	Mt. Sinai Hospital	Artesian Drlg.	1937	22	6	111 p	100	Krf	50	37	11-21-38	40	....	A	....
167	K23a-4045	Consumer Brewing Co.	Harper	1904	31	6	48 f	28	Qcm	35	10	1904	70	....	X	....
168	K23a-4045	do.	do.	1915	31	6	48 f	48	Qcm	35	10	1915	50	....	X	....
169	K23a-4045	Trainer Brewing Co.	....	1933	31	8	60 f	57	Qcm-Krf	40	35	1933	150	....	X	....
170	K23a-4250	Italia Theater	Ridpath & Potter	1941	31	8	93 f	74	Krf	10	34	2-22-41	80	7	A	....
171	K23a-4656	P. C. Tomson	Rulon	1916	15	8	200 f	138	Krf	30	35	1916	150	....	X	....
172	K23a-4455	Browns Frosted Foods	Ridpath & Potter	1939	22	8	105 f	86	Krf	35	23	2-14-39	......	....	I	C
173	K23a-4352	Haps Ice Cream	Rulon	1938	31	6	86 f	......	Krf	15	....	....	......	....	X	....
174	K23a-3847	Gladstone Hotel	Harper	....	37	6	576 p 250 f	......	Pk	....	31	1893	80	4	X	....

175	K23a-3948	C. E. Johnson & Co.	Artesian Drlg.	1915	35	10	84 f	84	Pk-Qcm	....	29	1915	100	....	A,I	C
176	K23a-3956	Quaker City Cold Storage	Ridpath & Potter	1927	10	6	88 f	88	Krf	30	10	2-27	350	....	U	....
177	K23a-3956	do.	Artesian Drlg.	....	10	12	78 f	63	Krf	35	17	1-8-38	350	15	U	....
178	K23a-3856	do.	do.	1930	10	8	235 f	89	Krf	39	13	5-19-54	150	....	U	....
179	K23a-4156	American Bag & Paper Co.	....	1940	20	....	......	......	....	....	....	....	......	....	I	....
180	K23a-4154	Sklaroff & Sons	Ridpath & Potter	1913	32	8	119 f	52	Krf	40	40	9-10-13	40	....	I	C
181	K23a-4054	Abbotts Dairies	Harper	1911	30	10	77 f	......	Krf	45	45	8-52	200	....	I	C
182	K23a-4054	do.	Artesian Drlg.	1915	30	10	94 f	......	Krf	45	34	1915	......	....	X	....
183	K23a-4054	do.	do.	1918	30	10	88 f	......	Krf	45	32	1918	......	....	X	....
184	K23a-4054	do.	do.	1940	30	10	80 f	......	Krf	45	41	8-52	260	....	I	C
185	K23a-3954	do.	do.	1940	29	10	86 f	......	Krf	44	38	8-52	250	....	I	C
186	K23a-3645	John Bartram Hotel	Harper	....	42	8	525 f	......	Pk	....	....	....	70	....	X	....

TABLE 11.—RECORD OF WELLS. Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
187	K23a-3855	National Publishing Co.	Rulon	1923	21	4	31 f	......	Qcm	51	....	....	......	....	X	....
188	K23a-3648	Horn & Hardart Baking Co.	do.	1925	35	6	400 f	......	Pk	....	35	1-4-54	70	....	U	....
189	K23a-3550	Continental Hotel	Harper	....	35	8	240 f	......	Pk	....	....	....	40	....	X	....
190	K23a-3651	Curtis Publishing Co.	....	1914	29	8	500 f	......	Krf	28	31	1-14-54	150	....	U	....
191	K23a-3655	Gross Building	Harper	1903	19	8	251 f	113	Pk	....	12	1903	40	....	X	....
192	K23a-3750	Pa. Hospital	Artesian Drlg.	1926	35	4	50 f	50	Qcm	30	17	1926	10	....	X	....
193	K23a-3346	John Wanamaker & Son	Ridpath & Potter	1937	45	6	190 f	......	Pk	....	46	5-21-37	5	<1	X	....
194	K23a-3547	Saull's Laundry	Kelsey	....	35	8	266 p 265 f	......	Qcm	35	28	1890	100	....	X	....
195	K23a-3545	Witherspoon Building	....	....	45	4	300 f	......	Pk	....	45	5-18-54	80	....	U	....

196	K23a-3445	North American Building	Harper	1902	45	8	750 f	28	Pk	....	47	5-18-54	50	....	U	....
197	K23a-3547	Camac Turkish Baths	Ridpath & Potter	1934	40	8	500 f	66	Pk	....	40	7-30-34	5	<1	X	....
198	K23a-3447	Greenfield Building	Harper	1910	41	6	200 f	36	Pk	....	6	1910	30	....	X	....
199	K23a-3347	Phila. Saving Fund Society	Sprague & Henwood	1931	45	10	487 f	49	Pk	....	36	1931	350	....	U	....
200	K23a-3347	do.	do.	1931	45	10	494 f	49	Pk	....	43	3-10-54	300	4	U	....
201	K23a-3457	Girard Packing Co.	Ridpath & Potter	1939	12	8	64 f	51	Krf	28	17	1-24-39	100	....	I	....
202	K23a-3457	do.	Artesian Drlg.	1943	12	8	62 f	54	Krf	28	19	1943	70	5	I	P
203	K23a-3457	do.	do.	1954	10	....	......	......	Krf	28	11	10-6-54	240	....	I	C
204	K23a-3257	Lummis & Co.	Harper	1918	10	8	74 f	74	Krf	30	13	1918	60	....	X	....
205	K23a-3257	do.	Ridpath & Potter	1928	10	8	61 f	42	Krf	30	2	8-25-28	60	20	I	C
206	K23a-3158	M. Wildstein & Co.	do.	1948	20	8	61 f	40	Krf	30	12	7-20-48	270	....	I	C
207	K23a-3154	Whitman & Son	Harper	1906	35	6	498 f	71	Pk	....	47	1906	3	....	X	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer		Water level		Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
									Formation	Thickness (feet)	Depth below land surface (feet)	Date of measurement				
208	K23a-3154	Whitman & Son	Harper	1910	35	6	67 f	57	Krf	23	....	....	20	....	X	....
209	K23a-3156	J. E. Lonergan Co.	Quinn & Herron	1910	35	8	200 f	70	Krf	26	22	1910	30	....	X	....
210	K23a-3156	H. O. Wilbur & Sons	Harper	1904	34	8	363 f	67	Pk	....	16	1904	60	....	X	....
211	K23a-3046	Gilbert Building	do.	1911	42	8	340 f	53	Pk	....	22	1911	120	....	X	....
212	K23a-2952	Hygeia Ice Co.	Flemstrom	1900	35	8	400 f	20	Pk	....	32	1895	70	....	X	....
213	K23a-2952	do.	Quinn & Herron	1911	38	8	227 f	42	Pk	....	29	1911	50	....	X	....
214	K23a-2647	Stainless Steel Sales Corp.	Rulon	1920	50	6	210 f	......	Pk	....	....	....	......	....	X	....
215	K23a-2749	H. B. Underwood Corp.	Harper	1910	40	6	172 f	6	Pk	....	3	1910	3	....	X	....
216	K23a-2750	Armour & Co.	Quinn & Herron	1907	39	8	300 f	28	Pk	....	26	1907	100	....	X	....

217	K23a-2751	Quaker Salad Co.	Quinn & Herron	1908	37	6	135 f	36	Pk	....	40	1908	40	....	X	....
218	K23a-2751	Helwig Silk Co.	do.	1910	37	8	250 f	35	Pk	....	40	1910	50	....	X	....
219	K23a-2852	Kingan & Co.	do.	1910	32	8	38 f	20	Qcm	10	32	1910	10	....	U	....
220	K23a-2852	do.	do.	1910	32	8	38 f	20	Qcm	10	32	1910	10	....	U	....
221	K23a-2852	do.	do.	1910	32	8	38 f	20	Qcm	10	32	1910	......	....	U	....
222	K23a-2852	do.	do.	1910	32	8	38 f	20	Qcm	10	32	1910	......	....	U	....
223	K23a-2848	Wolf Bros.	Harper	1907	40	8	317 f	78	Pk	....	22	1907	......	....	X	....
224	K23a-2854	Betz Brewery	do.	....	27	10	1,000 f	......	Pk	....	....	....	......	....	X	....
225	K23a-2854	Crescent Ink & Color Co.	Phila. Drlg.	1949	30	8	260 f	112	Pk	....	17	1949	......	....	I	C
226	K23a-2856	Charles J. Matthews	Quinn & Herron	1906	27	6	200 f	42	Pk	....	14	1906	......	....	U	....
227	K23a-2856	do.	do.	1907	25	6	200 f	42	Pk	....	24	1907	......	....	X	....
228	K23a-2657	Sweetie Beverages	Ridpath & Potter	1937	33	8	500 f	54	Pk	....	30	6-10-37	......	....	I	P

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location no.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
229	K23a-2548	Union Traction Co.	Harper	1894	55	8	2,031 f	15	Pk	....	12	1894	......	....	X	....
230	K23a-2648	Bilgram Gear & Machine	do.	1910	50	6	529 f	......	Pk	....	26	11-4-53	......	....	I	....
231	K23a-2457	Ortlieb Brewing Co.	....	1900	32	60	40 f	40	Qcm	52	....	....	......	....	I	....
232	K23a-2457	do.	....	1900	31	60	40 f	40	Qcm	51	....	....	......	....	I	....
233	K23a-2457	do.	....	....	31	60	40 f	......	Qcm	51	....	....	......	....	I	....
234	K23a-5452	Morgenthaler Bros.	Artesian Drlg.	1917	12	8	170 f	160	Krf	51	22	1917	300	....	I	....
235	K23a-5452	do.	do.	1920	12	10	164 f	154	Krf	51	23	1920	270	....	I	C
236	K23a-5452	do.	do.	1924	12	10	160 f	150	Krf	51	22	1924	350	....	I	....
237	K23a-5452	do.	do.	1928	12	10	164 f	154	Krf	51	23	1928	500	....	I	C

238	K23a-5452	Morgenthaler Bros.	Artesian Drlg.	1932	12	10	158 f	148	Krf	51	....	....	......	....	I	....
239	K23a-5452	do.	do.	1933	12	10	168 f	158	Krf	51	23	1933	270	....	I	....
240	K23a-5452	do.	do.	1945	12	10	155 p	118	Krf	51	....	....	350	....	I	....
241	K23a-5356	Spatola Wines	do.	1934	13	8	151 f	151	Krf	35	48	1934	300	....	U	....
242	K23a-5356	do.	do.	1939	13	8	165 f	145	Krf	35	....	....	300	....	U	C
243	K23a-2456	Phila. Dairy Products	....	....	32	82	33 f	......	Qcm	20	....	....	......	....	I	....
244	K23a-2456	Henry Hess Brewing Co.	Harper	1911	35	8	181 f	51	Pk	....	30	1911	......	....	U	....
245	K23a-2456	Phila. Dairy Products	....	1938	35	12	500 f	......	Pk	....	23	12-10-53	......	....	U	....
246	K23a-4753	Quaker Maid Dairies	Rulon	1932	25	8	72 f	61	Krf	18	31	12-29-34	......	....	X	....
247	K23a-4753	do.	Artesian Drlg.	1940	24	8	109 f	......	Krf	20	....	....	100	....	I	P
248	K23a-4054	Cahan Sugar Refinery	do.	1912	15	6	140 p 105 f	117	Krf	46	....	....	190	....	U	....
249	K23a-4954	Crown Paper Board Co.	Cook	1940	13	8	156 p	136	Krf	47	36	1940	200	50	U	P

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
250	K23a-4954	Crown Paper Board Co.	Harper	1925	13	8	108 f	108	Krf	47	18	1925	200	....	I	C
251	K23a-4953	Quaker City Dairy Co.	Artesian Drlg.	1915	18	8	109 f	109	Krf	50	10	1915	100	....	X	....
252	K23a-2259	Schmidt & Sons	Ridpath & Potter	1949	18	12	36 f	19	Qcm	34	16	6-10-49	......	8	I	C
253	K23a-2258	do.	do.	1949	18	8	1,000 f	60	Pk	....	17	8-26-49	......	<1	U	....
254	K23a-2159	do.	....	....	20	96	38 f	......	Qcm	36	21	6-13-54	......	....	I	....
255	K23a-2958	A. Golin	....	1949	10	8	62 f	40	Krf	15	8	2-19-49	......	....	I	....
256	K23a-2855	E. Hubschman & Sons	Ridpath & Potter	1937	25	8	253 f	51	Krf	4	14	6-3-37	......	....	U	....
257	K23a-2758	Phila. Warehousing & Cold Storage Co.	Harper	1909	15	8	27 f	10	Qcm	20	2	1909	......	....	I	....
258	K23a-2758	do.	do.	1909	15	8	27 f	10	Qcm	20	2	....	......	....	I	....

259	K23a-2758	Phila. Warehousing & Cold Storage Co.	Harper	1909	15	8	27 f	10	Qcm	20	....	....	......	....	I	....
260	K23a-2758	do.	do.	1909	15	8	27 f	10	Qcm	20	....	....	......	....	I	....
261	K23a-2859	do.	Artesian Drlg.	1915	15	6	62 f	62	Qcm	50	....	....	......	....	X	....
262	K23a-2859	do.	do.	1917	15	8	49 f	49	Qcm	40	....	....	......	....	X	....
263	K23a-2859	do.	do.	1917	15	8	50 f	50	Qcm	40	....	....	......	....	X	....
264	K23a-2859	do.	do.	1917	15	8	51 f	51	Qcm	40	....	....	......	....	X	....
265	K23a-2858	do.	do.	1935	15	10	50 f	......	Qcm	60	....	....	......	....	I	....
267	K23a-2360	Nicholson File Co.	....	......	14	6	340 f	......	Pk	....	....	....	......	....	X	....
268	K23a-2360	do.	....	....	14	6	240 f	......	Pk	....	....	....	......	....	X	....
269	K23a-2360	do.	Artesian Drlg.	1941	14	8	400 f	62	Pk	....	....	....	......	....	X	....
270	K23a-2361	do.	do.	1941	14	8	245 f	65	Pk	....	....	....	......	....	I	C
271	K23a-2462	Pa. Sugar Co.	Harper	1912	10	8	64 f	52	Pk	....	30	1912	......	....	X	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location no.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer		Water level		Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
									Formation	Thickness (feet)	Depth below land surface (feet)	Date of measurement				
272	K23a-2462	Pa. Sugar Co.	Harper	1912	10	8	69 f	58	Pk	....	30	1912	......	....	X	....
273	K23a-2462	do.	do.	1912	10	6	215 f	67	Pk	....	....	....	......	....	X	....
274	K23a-2562	do.	Ridpath & Potter	1931	8	8	390 f	126	Pk	....	12	7-22-31	......	2	U	P
275	K23a-2562	do.	do.	1945	13	10	400 p	72	Pk	....	22	12-26-45	......	<1	U	....
276	K23a-2162	Stockwell Rubber Co.	Artesian Drlg.	1938	21	8	85 f	65	Pk	....	28	1938	......	....	X	....
277	K23a-2263	Joseph H. Smith & Co.	Rulon	1946	22	8	225 f	33	Pk	....	21	1-46	......	<1	I	C
278	K23a-2358	American Stores Co.	Artesian Drlg.	1919	17	6	21 f	21	Qcm	37	32	1919	......	....	X	....
279	K23a-2358	do.	do.	1920	18	6	26 f	26	Qcm	38	32	1920	......	....	X	....
280	K23a-2160	Shearer's Dairies	do.	1930	18	4	30 f	30	Qcm	35	14	1930	......	....	I	....

281	K23a-2060	Shearer's Dairies	Ridpath & Potter	1952	18	8	38 f	33	Qcm	35	14	4-18-52	......	....	I	C
282	K23a-2057	Louis Buck	Harper	1904	23	10	750 f	54	Pk	....	18	9-14-49	......	<1	U	....
283	K23a-2056	Jones Dairy	Rulon	1916	22	8	380 f	25	Pk	...	18	4-16	......	....	X	....
284	K23a-2850	Esslinger's	....	1900	25	8	300 f	......	Pk	....	....	....	......	....	U	....
285	K23a-2850	do.	Rulon	1935	25	8	524 f	......	Pk	....	....	....	......	....	X	....
288	K23b-1503	National Lead Co.	Sutton & Stephenson	1919	15	168	22 f	22	Qcm	10	9	1-8-54	......	....	I	C
290	K23a-3148	David Wilson	Harper	1909	45	8	348 f	11	Pk	....	44	2-25-54	......	....	U	....
291	K23a-3347	Reading Co.	do.	1910	45	8	244 f	85	Pk	....	23	1910	......	....	X	..
292	K23a-3347	E. P. Smith	Harper	1910	45	10	240 f	28	Pk	....	33	1910	......	....	X	...
293	K23a-3251	Strawbridge & Clothier	do.	1917	38	8	735 f	80	Pk	....	45	3-12-54	......	....	U	....
294	K23a-3351	do.	....	1934	38	12	62 f	42	Qcm	20	48	3-4-54	......	....	U	....
295	K23a-2352	Merck & Co.	Harper	1911	40	6	281 f	22	Pk	....	34	1911	......	...	X	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location no.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
296	K23a-2352	Merck & Co.	Harper	1921	40	6	287 f	29	Pk	....	18	1921	......	....	X	....
297	K23a-2052	Cudahy Packing Co.	....	1920	50	8	135 f	......	Pk	....	15	5-12-54	......	....	U	....
298	K23a-2052	Swift & Co.	Artesian Drlg.	1925	45	6	200 f	......	Pk	....	13	1925	......	....	U	P
299	K23a-2648	Parkway Baking Co.	....	1935	53	8	650 f	......	Pk	....	....	....	......	....	U	....
300	K23a-3048	Godfrey Roller Co.	Rulon	1950	45	6	278 f	150	Pk	....	41	1-6-50	......	5	I	C
301	K23b-1116	Neatsfoot Oil Refineries	....	1910	13	8	400 f	......	Pk	....	9	7-15-53	......	....	U	....
302	K23b-1116	do.	Ridpath & Potter	1940	12	6	65 f	55	Krf	5	10	6-27-40	......	....	U	....
304	K23b-0815	Aldan Rubber Co.	Rulon	1939	14	8	300 f	150	Pk	....	....	... .	......	....	I	C
305	K23b-1016	Dill & Collins	Harper	1902	13	8	500 f 130 p	75	Pk	....	15	1902	......	....	X	P

306	K23b-1216	Mutual Rendering Co.	Artesian Drlg.	1924	10	8	72 f	......	Qcm Krf	5	7	1924	......	....	I	P
307	K23b-0630	F. S. Walton & Son	Harper	1903	8	8	55 f	41	Qcm	55	5	1903	......	....	X	....
308	K23b-1014	Enterprise Fallow & Grease Co.	Artesian Drlg.	1928	12	6	55 f	50	Qcm	52	9	1928	......	....	I	C
309	K23b-1014	do.	do.	1942	12	8	70 f	......	Pk	....	....	....	......	....	U	....
310	K23b-0916	Jersey Queen Dairy	....	1940	15	8	180 f	......	Pk	....	11	1-29-54	......	....	U	....
311	K23b-0916	do.	Rulon	1944	15	8	53 f	......	Qcm	50	....	....	......	....	I	P
312	K23b-1219	Phila. Gas Works	Harper	1903	8	6	430 f	63	Pk	....	10	1903	......	....	X	....
313	K23b-1220	M. L. Shoemaker & Co.	do.	1905	8	8	74 f	66	Krf	15	6	1905	120	....	X	....
314	K23b-1220	do.	do.	1905	8	8	407 p 70 f	60	Krf	15	9	1905	70	....	X	....
315	K23b-1220	do.	do.	1912	8	6	500 p	60	Krf	15	6	1912	130	....	X	....
316	K23b-0627	American Smelting	Ridpath & Potter	1914	8	8	200 f	82	Pk	....	3	8-12-14	......	....	U	....
317	K23b-0527	do.	....	1920	8	6	400 f	....	Pk	....	....	....	......	....	I	C

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
318	K23b-0318	F. W. Tunnell & Co.	....	1900	18	6	400 f	....	Pk	....	....	....	......	....	U	....
319	K23b-0318	do.	....	1900	18	60	22 f	....	Qcm	47	....	....	......	....	U	....
320	K23b-0318	do.	Tunnell	1900	18	138	40 f	....	Qcm	47	24	7-22-53	......	....	I	....
321	K23b-0418	do.	Layne-New York	1937	20	12	49 p 45 f	30	Qcm	49	14	8-31-37	......	26	U	....
322	K23b-0318	do.	Tunnell	1945	18	102	43 f	40	Qcm	49	11	9-28-53	......	....	I	....
323	K23b-0629	Liberty Corp.	....	1930	10	6	110 f	....	Pk	....	12	8-31-53	......	....	U	P
324	J23d-8433	Rohm & Haas Co.	Layne-New York	1934	11	6	67 p	....	Krf	20	20	5-7-34	......	....	X	....
325	J23d-8333	do.	do.	1934	10	6	80 p	....	Krf	20	20	5-14-34	......	....	X	....
326	J23d-8332	do.	do.	1934	18	6	65 p	....	Krf	23	20	5-21-34	......	....	X	....

327	J23d-8330	Rohm & Haas Co.	Layne-New York	1934	10	6	44 p	....	Krf	5	8	5-25-34	......	....	X	....
328	J23d-7832	Simonds Abrasive Co.	Ridpath & Potter	1918	25	8	254 f	....	Pk	....	16	7-24-53	......	....	U	....
329	J23d-8027	Delta File Works	do.	1935	20	6	156 f	32	Pk	....	18	7-19-35	......	3	I	C
330	K23b-0315	Reid Metal Refining Co.	....	....	18	....	....	....	....	....	....	....	......	....	I	....
332	J23d-8420	Bers & Co.	Rulon	1941	10	8	150 f	30	Pk	....	6	7-29-53	......	....	U	....
333	J23d-8320	Louis J. Gedicke & Sons	Ridpath & Potter	1933	20	6	94 f	27	Pk	....	14	8-4-33	......	<1	U	....
334	J23d-8123	Whiting & Patterson	Harper	1918	26	8	182 f	80	Pk	....	24	1918	......	....	X	....
335	J23d-8123	do.	Ridpath & Potter	1942	27	6	752 f	124	Pk	....	21	2-20-42	......	<1	U	....
336	J23d-8026	Blumenthal Bros.	Artesian Drlg.	1916	25	6	511 f	14	Pk	....	17	1916	......	....	X	P
337	J23d-8025	do.	do.	1918	30	8	244 f	19	Pk	....	18	1918	......	....	I	P
338	J23d-8026	do.	Ridpath & Potter	1935	25	8	342 f	28	Pk	....	40	12-9-35	......	<1	I	P
341	J23d-7837	Quaker Rubber Corp.	do.	1936	10	16	42 f	24	Krf	15	8	5-28-36	120	....	X	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
342	J23d-7737	Quaker Rubber Co.	Ridpath & Potter	1947	15	8	501 f	69	Pk	....	10	6-4-36	......	1	U	....
343	J23d-7737	do.	do.	1936	15	16	31 f	11	Qcm	20	5	7-21-36	......	20	X	....
344	J23d-8023	do.	do.	1950	30	8	250 f	44	Pk	....	13	1-30-53	......	1	I	C
345	J23d-7838	Quaker Rubber Corp.	Layne-New York	1953	8	8	48 f	....	Krf	10	10	3-16-53	120	4	X	....
346	J23d-7340	Linear Inc.	Artesian Drlg.	1920	30	8	181 f	20	Qcm	50	10	1920	......	....	I	....
347	J23d-7340	do.	do.	1952	30	....	420 f	....	Pk	....	....	....	......	....	I	C
348	J23d-7439	Crystal Soap & Chemical	Harper	1918	30	6	75 f	33	Qcm	50	20	1918	......	....	U	....
349	J23d-7937	Helwig Dyeing Corp.	Quinn & Herron	1913	8	8	226 f	65	Pk	....	19	1913	......	....	X	....
350	J23d-7934	Frankford Arsenal	Harper	1907	15	8	82 f	59	Pk	....	20	1907	......	....	X	....

351	J23d-7935	International Shoe Co.	Artesian Drlg.	1929	13	8	36 f	36	Krf	10	20	1929	250	....	X	....
352	J23d-8036	do.	do.	1932	8	8	344 f	....	Pk	....	30	11-6-34	......	1	U	....
353	J23d-7835	do.	do.	1933	15	16	41 f	10	Qcm	25	....	....	......	7	I	....
354	J23d-8036	do.	do.	1934	5	8	330 f	....	Pk	....	20	11-6-34	......	1	U	....
355	J23d-7342	Dodge Steel Co.	Harper	1903	20	6	300 f	34	Krf	10	19	1903	......	....	X	....
356	J23d-7343	do.	do.	1906	18	6	317 f	29	Pk	....	12	1906	......	....	X	....
357	J23d-6849	Kessler Chemical Co.	Stothoff	1942	20	8	201 p	34	Pk	....	26	11-42	......	2	I	C
358	J23d-6748	U. S. Rubber Co.	Cook	1938	35	8	260 f	60	Pk	....	19	9-1-53	......	....	U	....
359	J23d-7342	Dodge Steel Co.	....	....	22	6	305 f	....	Pk	....	22	5-14-37	......	....	U	....
360	J23d-7051	L. Martin Co.	Artesian Drlg.	1935	10	12	38 f	38	Qcm-Krf	35	10	1935	......	....	U	....
361	J23d-7639	L.Blumberg & Son	Ridpath & Potter	1943	10	12	35 p	17	Qcm-Krf	19	10	5-27-43	......	15	X	....
362	J23d-7735	Mulholland-Harper Co.	do.	1935	26	8	305 f	67	Pk	....	24	11-27-35	......	8	X	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location no.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
363	J23d-8227	Allied Chemical & Dye Corp.	Rulon	1935	10	12	42 f	....	Qcm	30	....	....	......	....	X	....
364	J23d-8228	do.	do.	1935	10	12	40 f	....	Qcm	30	....	....	......	....	X	....
365	J23d-8228	do.	do.	1935	9	12	40 f	....	Qcm	30	....	....	......	....	X	....
366	J23d-8229	Sam Berstein & Co.	do.	1933	10	14	32 f	....	Qcm	40	....	....	......	....	X	....
367	J23d-8229	Fishman & Sons	Artesian Drlg.	1938	9	12	34 f	24	Qcm	39	28	1938	......	....	X	....
368	J23d-8420	Joseph Bernliner Co.	....	1910	15	20	25 f	....	Qcm	35	....	....	......	....	I	....
369	J23d-8520	do.	....	....	10	6	100 f	....	Pk	....	....	....	......	....	I	....
370	J23d-7925	Blue Magic Inc.	Ridpath & Potter	1950	31	6	575 f	132	Pk	....	37	6-2-50	......	<1	I	....
372	J23d-6952	Pa. Forge Co.	do.	1941	10	10	40 p	29	Krf	15	6	11-25-41	......	2	X	....

373	J23d-7053	Pa. Forge Co.	Layne-New York	1942	8	16	47 f	37	Krf	15	8	2-5-42	310	12	I	C
374	J23d-7054	do.	do.	1942	5	10	42 f	32	Krf	15	10	3-16-42	230	12	U	....
376	K23b-0017	George Sall Metals Co.	Ridpath & Potter	1952	26	8	37 f	22	Qcm	46	8	4-1-52	......	2	X	....
377	K23b-0218	Independent Mfg. Co.	....	1927	18	6	300 f	....	Pk	....	....	....	......	....	X	....
378	J23d-7922	Globe Mfg. Co.	Harper	1905	38	6	100 f	62	Pk	....	12	1905	......	....	X	....
379	J23d-8022	Globe Dye Works Co.	do.	1900	34	6	335 f	....	Pk	....	....	....	......	....	X	....
384	K23b-1013	Richmond Lumber Co.	Rulon	1923	15	8	342 f	....	Pk	....	....	....	......	....	X	....
385	K23b-0413	Liquid Carbonic Corp.	Harper	1920	19	8	160 f	15	Pk	....	20	1920	......	....	X	....
386	K23b-0413	Seven-Up Bottling	Rulon	1940	19	10	175 f	49	Pk	....	....	....	......	....	X	....
387	K23b-0514	Jacob Stern & Sons	Artesian Drlg.	1933	17	6	50 f	50	Pk	....	15	1933	......	....	X	....
388	K23b-0609	Food Fair Stores	Harper	1915	18	8	553 f	....	Pk	....	13	12-4-53	......	....	U	....
389	K23b-1114	General Smelting Co.	Rulon	1931	10	10	55 p	45	Qcm	21	....	....	......	....	I	C

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location no.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
390	K23b-1114	General Smelting Co.	Rulon	1946	10	10	46 f	36	Qcm	21	9	10-19-46	......	....	I	....
391	K23b-0608	Brehm & Stehle	Harper	1904	20	8	206 f	53	Pk	....	27	1904	......	....	X	....
392	K23b-0408	Phila. Rust Proof Co.	Ridpath & Potter	1940	25	6	478 f	185	Pk	....	15	5-8-40	......	....	I	C
393	K23b-0408	do.	Rulon	1941	25	6	500 f	....	Pk	....	....	....	......	....	X	....
394	K23b-0409	Scholler Bros.	Ridpath & Potter	1947	23	8	505 f	47	Pk	....	25	8-21-47	......	....	X	....
395	K23b-0410	do.	Artesian Drlg.	1951	23	8	583 f	....	Pk	....	25	1951	......	....	I	P
397	J24c-5005	Convent of Sacred Heart	....	1900	60	60	17 f	....	Qcm	....	4	1-21-54	......	....	Irr	....
398	J23d-5760	James D. Morrissey	Rulon	1950	38	6	213 f	40	Pk	....	8	8-25-50	......	<1	I	P
399	J24c-4808	Pa. Railroad Co.	Harper	1900	25	6	215 f	20	Pk	....	18	1895	......	....	X	....

401	K23a-5555	Wilson-Martin Co.	Artesian Drlg.	1919	14	12	186 f	186	Krf	50	----	----------	250	----	I	----
402	K23a-5555	do.	do.	1923	14	12	164 f	160	Krf	48	20	1923	250	----	I	----
403	K23a-6261	Publicker Industries	--------	1928	8	----	--------	----	--------	----	----	----------	------	----	U	----
406	K23a-6360	do.	--------	--------	8	----	--------	----	--------	----	----	----------	------	----	U	----
407	K23a-6362	do.	Layne-New York	1937	8	18	196 p 189 f	159	Krf	41	48	8-21-37	1,030	25	I	C
408	K23a-6262	do.	Rulon	1939	8	10	194 f	154	Krf	35	66	6-2-39	1,050	27	I	----
409	K23a-6460	do.	do.	1940	8	16	90 f	70	Qcm	20	----	----------	400	----	U	----
410	K23a-6460	do.	do.	1940	8	16	152 f	----	Krf	17	78	6-19-40	800	----	X	----
411	K23a-6261	do.	Layne-New York	1941	10	18	87 p 82 f	58	Qcm	17	11	4-26-41	------	33	I	C
412	K23a-6361	do.	do.	1941	10	18	96 p 85 f	60	Qcm	14	20	7-18-41	------	31	I	C
413	K23a-6362	do.	Layne-New York	1942	10	18	80 p 76 f	56	Qcm	24	19	10-19-42	------	26	I	----
414	K23a-6460	do.	do.	1942	10	16	87 p 83 f	63	Qcm	37	33	12-3-42	------	33	I	

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
415	K23a-6360	Publicker Industries	Layne-New York	1943	8	16	92 f	72	Kro	15	34	1-22-43	......	22	I	....
416	K23a-6362	do.	do.	1943	10	16	90 p 89 f	69	Qcm	22	39	7-8-43	......	30	I	....
417	K23a-6361	do.	do.	1943	9	10	172 p 165 f	145	Krf	16	72	10-4-43	730	16	I	....
418	K23a-6260	do.	do.	1943	10	10	155 p 149 f	129	Krf	21	70	11-19-43	780	17	I	....
419	K23a-6361	do.	do.	1944	9	10	167 p 155 f	135	Krf	17	92	5-21-44	740	17	I	....
420	K23a-6462	do.	do.	1944	8	10	171 p 164 f	149	Krf	29	90	10-18-44	710	23	I	....
421	K23a-6660	do.	do.	1945	8	16	96 f	76	Qcm	20	25	6-18-45	......	14	U	....
422	K23a-6760	do.	do.	1945	8	16	107 f	87	Qcm	20	25	6-18-45	......	12	U	....
423	K23a-6358	do.	do.	1945	8	10	192 p 191 f	171	Krf	17	82	8-4-45	300	4	X	....

425	K23a-6260	Cargill, Inc.	Rulon	1926	8	6	182 f	....	Krf	40	....	....	......	....	X	....
426	K23a-6260	do.	do.	1945	10	10	178 p	158	Krf	48	93	1-5-45	500	29	I	P
427	K23a-5258	Baugh & Sons Co.	Artesian Drlg.	1912	8	8	133 f	133	Krf	35	9	1912	200	....	X	....
428	K23a-5258	do.	do.	1912	8	8	140 f	140	Krf	35	12	1912	150	....	X	....
429	K23a-5258	do.	do.	1913	8	8	140 f	140	Krf	35	18	1913	150	....	X	....
430	K23a-5056	Crown Paper Board Co.	Layne-New York	1952	10	10	160 p 128 f	108	Krf	36	32	6-5-52	550	20	I	C
431	K23a-5156	Phila. Extracting Co.	Harper	1909	11	6	122 f	110	Krf	35	14	1909	70	....	X	....
432	K23a-5654	Harshaw Chemical Co.	do.	1914	14	8	890 f	190	Pk	....	80	1914	......	....	X	....
433	K23a-5554	do.	Artesian Drlg.	1914	14	10	190 f	190	Krf	55	13	1914	550	....	X	....
434	K23a-5654	do.	do.	1927	11	12	168 p	166	Krf	50	30	1927	400	......	U	C
435	K23a-5654	do.	Ridpath & Potter	1934	14	10	158 f	133	Krf	55	68	5-30-34	500	71	X	....
436	K23a-5554	do.	Artesian Drlg.	....	13	12	175 p	175	Krf	45	....	....	400	......	U	C

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer		Water level		Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
									Forma-tion	Thickness (feet)	Depth below land surface (feet)	Date of measurement				
437	K23a-5354	India Refining Co.	Artesian Drlg.	1918	11	8	150 f	109	Krf	30	20	1918	200	....	X	....
438	K23a-4849	Stratford Theater	Rulon	1937	24	8	86 f	....	Krf	26	....	....	50	....	A	....
439	K23a-5449	Academy Theater	Ridpath & Potter	1938	17	8	132 f	101	Krf	45	31	5-10-38	420	10	A	....
440	K23a-5449	Jackson Theater	do.	1936	17	8	82 f	62	Qcm	60	32	5-7-36	......	....	A	....
441	K23a-6207	Pa. Flexible Metallic Tubing Co.	Harper	1918	10	8	620 f	42	Pk	....	....	....	......	....	X	....
442	K23a-6309	Hog Island Lumber Co.	....	....	10	6	97 f	....	Pk	....	16	12-2-46	......	<1	I	C
443	K23a-7508	Alfonso DePalma	Ridpath & Potter	1952	8	6	78 f	68	Pk	....	11	4-18-52	......	....	I	C
444	K23a-7402	Hodges Record Co.	do.	1952	5	8	200 f	66	Pk	....	....	....	......	1	I	C
445	K23a-7204	Penn City National Oil Co.	Artesian Drlg.	1933	5	4	38 f	36	Qcm	60	....	....	......	....	X	....

446	K23a-7205	American Iron Works	Rulon	1923	5	12	62 f	....	Qcm	60	8	5-26-54	......	....	U	....
447	K23a-5316	Regal Petroleum Products Co.	Ridpath & Potter	1947	20	8	351 p	22	Pk	....	4	10-24-47	......	2	U	....
451	K23a-5454	Continental Distilling Corp.	Layne-New York	1933	11	14	170 p	124	Krf	35	28	12-8-33	1,080	25	I	....
452	K23a-5455	do.	do.	1933	11	14	164 p 160 f	130	Krf	50	44	12-30-33	1,100	37	I	....
453	K23a-5455	do.	Rulon	1940	13	12	159 f	....	Krf	50	64	8-4-54	......	....	U	....
454	K23a-5455	do.	Layne-New York	1941	13	18	50 f	40	Qcm	68	23	7-1-41	......	14	I	....
455	K23a-5454	do.	Ridpath & Potter	1941	13	8	155 f	96	Krf	35	62	8-10-41	......	..	I	....
456	K23a-5454	do.	do.	1941	13	10	156 f	....	Krf	32	68	10-31-41	......	....	X	....
457	K23a-5355	do.	Layne-New York	1941	11	12	152 p 139 f	119	Krf	27	70	10-2-41	620	14	I	....
458	K23a-5554	do.	do.	1944	11	10	168 p 152 f	127	Krf	31	75	6-5-44	710	16	I	....
459	K23a-5355	do.	do.	1944	11	10	160 p 157 f	127	Krf	38	79	6-5-44	740	21	I	....
460	K23a-5554	do.	Ridpath & Potter	1945	13	10	172 f	151	Krf	42	80	2-12-45	370	6	I	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location no.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
461	K23a-5056	Continental Distilling Corp.	Artesian Drlg.	1913	12	8	60 f	60	Qcm	52	12	1913	......	....	X	....
462	K23a-5056	do.	do.	1913	12	6	60 f	60	Qcm	52	15	1913	......	....	X	....
463	K23a5056	do.	do.	1913	12	8	112 f	112	Krf	35	15	1913	120	....	X	....
464	K23a-5056	do.	do.	1913	12	8	112 f	112	Krf	35	15	1913	120	....	X	....
465	K23a-5055	do.	Rulon	1925	14	8	157 f	....	Krf	35	....	....	500	....	I	....
460	K23a-5156	do.	do.	1926	12	8	165 f	....	Krf	35	....	....	700	....	I	....
467	K23a5155	do.	do.	1933	13	10	140 f	113	Krf	35	....	....	1,350	....	I	....
468	K23a-4655	do.	Ridpath & Potter	1942	17	10	113 f	89	Krf	24	29	10-16-42	......	11	U	....
469	K23a-5358	do.	Layne-New York	1948	10	10	128 p	118	Krs	17	41	10-21-48	......	16	I	C

470	K23a-5256	Continental Distilling Corp.	Layne-New York	....	10	....	....	....	....	....	....	....	......	....	I	....
471	K23a-5455	Wilson-Martin Co.	....	....	13	10	159 f	133	Krf	47	70	11-21-46	370	14	X	....
472	K23a-5555	do.	Layne-New York	....	13	10	165 p	....	Krf	47	....	....	250	....	I	....
473	K23a-5555	do.	Ridpath & Potter	1953	13	10	175 f	150	Krf	47	46	2-21-53	250	5	I	....
474	K23a-5452	Jerry Theater	do.	1938	16	8	130 f	112	Krf	39	38	5-14-38	370	....	A	....
475	K23a-5545	Colonial Theater	do.	1936	17	10	103 f	86	Krf	8	24	6-3-36	140	5	A	....
476	K23a-3039	Fleishmann's Bakery	do.	1937	20	8	271 f	20	Pk	....	28	10-5-37	......	<1	X	....
478	K23a-2544	U. S. Mint	Quinn & Herron	1906	65	8	1,000 f	....	Pk	....	3	1906	......	....	X	....
480	K23a-2446	Sharp & Dohme	Harper	1910	70	8	757 f	....	Pk	....	25	3-10-54	......	....	U	....
484	K23a-2645	Baldwin Locomotive Works	do.	1906	60	8	402 f	75	Pk	....	22	1906	......	..	X	....
485	K23a-2644	do.	do.	1906	60	8	425 f	65	Pk	....	6	1906	......	....	X	....
490	K23a-3240	Mastbaum Theater	Rulon	1929	30	12	484 f	....	Pk	....	....	....	......	....	X	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location no.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
491	K23a-3530	University of Pa.	Harper	1902	40	6	370 f	10	Pk	....	30	1902	......	....	X	....
492	K23a-3822	Breyer Ice Cream Co.	do.	1923	40	8	340 f	56	Pk	....	....	....	......	....	X	....
493	K23a-4422	Phila. Garbage Reduction Plant	Quinn & Herron	1905	15	8	442 f	28	Pk	....	5	1905	......	....	X	....
494	K23a-4419	Ryerson & Son	Harper	1902	40	8	200 f	9	Pk	....	....	....	......	....	X	....
495	K23a-4419	do.	do.	1906	40	8	528 f	....	....	....	....	....	......	....	X	....
503	K23a-3235	Pa. Cold Storage	do.	1913	20	8	300 f	50	Pk	....	....	....	......	....	X	....
504	K23a-3135	Martin Co.	do.	1907	25	8	191 f	27	Pk	....	....	....	......	....	X	....
505	K23a-3135	do.	do.	1907	25	8	400 f	25	Pk	....	....	....	......	....	X	....
506	K23a-3234	Abbotts Dairies	do.	1912	25	8	94 f	40	Pk	....	....	....	......	....	X	....

507	K23a-3234	Abbotts Dairies	Harper	1914	25	8	601 f	20	Pk	....	....	....	......	....	X	....
508	K23a-3234	do.	do.	1918	25	8	805 f	42	Pk	....	....	....	......	....	X	....
509	K23a-3334	Hajoca Corp.	Ridpath & Potter	1946	20	8	63 f	46	Pk	....	....	....	......	4	A,I	....
611	K23a-3252	U. S. Carbon & Ribbon Co.	Rulon	1952	40	6	400 f	65	Pk	....	....	....	......	<1	I	....
612	K23a-2749	Charles F. May Co.	do.	1949	40	10	435 f	27	Pk	....	21	9-2-49	......	6	U	....
613	K23a-1262	Harbisons Dairies	Harper	1906	30	6	162 f	15	Pk	....	16	1906	......	....	X	....
614	K23a-1262	do.	Rulon	1916	30	8	270 f	20	Pk	....	....	....	......	....	X	....
615	K23a-1365	Straubmuller Brewing	Quinn & Herron	1906	30	8	140 f	70	Pk	....	....	....	......	....	X	....
616	K23a-1264	Weisbrad-Hess Brewing	Rulon	1934	30	12	111 f	....	Pk	....	18	12-16-54	......	....	U	....
617	K23a-1163	D. Gordenberg	do.	1932	30	8	300 f	....	Pk	....	....	....	......	....	X	....
618	K23a-1063	Hart & Foster Co.	....	1914	30	6	308 f	....	Pk	....	....	....	......	....	X	....
619	K23b-0604	Kemper Furniture Co.	Haldeman	1948	30	....	....	....	Pk	....	....	....	......	....	A	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location no.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
620	K23b-0505	Atlantic Ice Co.	Harper	1906	30	8	300 f	22	Pk	....	61	1906	......	....	X	....
621	K23b-0409	Masland Duraleather Co.	....	1904	20	6	1,100 f	....	Pk	....	....	....	......	....	U	....
622	K23b-0508	do.	Artesian Drlg.	1937	20	6	175 f	....	Pk	....	....	....	......	....	X	....
623	K23b-0308	Thomas Wolstenholme Co.	Harper	1907	25	8	50 f	41	Pk	....	12	1907	......	....	X	....
624	K23b-0014	Schlichter Jute Cordage Co.	do.	1914	30	6	300 f	43	Pk	....	11	1914	......	....	X	....
625	K23b-0014	do.	....	1925	30	6	400 f	....	Pk	....	....	....	......	....	U	....
626	K23b-0014	do.	....	1925	30	6	500 f	60	Pk	..	15	6-54	......	....	I	....
627	J23d-8415	Industrial Dyeing & Finishing Co.	Harper	1909	30	8	131 f	50	Pk	....	37	1909	......	....	X	....
628	J23d-8313	James Lees & Sons	do.	1906	35	6	96 f	27	Pk	....	....	....	......	....	X	....

629	J23d-8116	Harbisons Dairies	Rulon	1921	25	8	525 f	....	Pk	....	40	4-5-21	......	....	X	....
630	J23d-8116	do.	do.	1921	25	8	524 f	....	Pk	....	40	12-3-21	......	....	X	....
633	K23a-1958	Schofield Co.	Harper	1919	30	8	76 f	11	Pk	....	....	....	......	....	X	....
634	K23a-1958	do.	do.	....	30	8	200 f	33	Pk	....	....	....	......	....	X	....
635	K23a-1760	Millside Dairies	Ridpath & Potter	1932	25	8	330 f	37	Pk	....	11	7-9-32	......	....	U	....
636	K23a-1659	Heidelberger Confectionery Co.	Rulon	1935	30	8	366 f	....	Pk	....	20	6-13-35	......	....	U	....
637	K23a-1658	Collins Mfg. Co.	Harper	1908	35	8	500 f	33	Pk	....	8	1908	......	....	X	....
638	K23a-1555	Richard P. McNeely	do.	1906	40	8	500 f	....	Pk	....	10	1906	......	....	X	....
639	K23a-1555	do.	do.	1907	40	8	226 f	14	Pk	....	15	1907	......	....	X	....
642	K23a-1357	Hutts Dairies	Ridpath & Potter	1930	45	6	500 f	....	Pk	....	58	10-24-39	......	<1	U	....
643	K23a-1361	Peter Herning & Sons	Rulon	1931	30	8	330 f	....	Pk	....	....	....	......	....	U	....
644	K23a-1260	Individual Milk Dealers Assoc.	do.	1935	35	8	300 f	....	Pk	....	..	....	......	....	X	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location no.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
667	J23d-8213	Bachmann Bros.	Ridpath & Potter	1949	50	8	462 f	35	Pk	....	22	1-24-49	......	<1	U	....
668	J23d-8214	do.	do.	1952	50	8	500 f	28	Pk	....	39	2-19-52	......	....	I	....
669	J23d-8509	Engil Milk Co.	Rulon	1934	40	8	300 f	....	Pk	....	....	....	......	....	X	....
671	K23b-0007	Philtex Mfg. Co.	do.	1934	50	10	550 f	....	Pk	....	....	....	......	....	X	....
727	K23a-6760	Pa. Railroad Co.	Layne-New York	1935	12	....	237 p	....	Krf	50	....	....	......	....	X	....
728	K23a-4955	N. & G. Taylor	Orcutt	1892	14	12	670 p	....	Pk	....	....	....	250	....	X	....
730	K23a-4856	Spreckles Sugar House	Flaghouse	1890	8	....	98 p	....	Krf	12	....	....	......	....	X	....
731	K23c-0118	E. N. Black	....	1885	10	....	456 p	....	Pk	....	....	....	......	....	X	....
732	K23a-2461	Unknown	....	1893	13	....	308 p	....	Pk	....	....	....	......	....	X	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
							BUCKS COUNTY									
479	J24c-4412	Margold Ribbon Mills	Haldeman	1948	30	40-6	63 p	....	Pk	....	....	....	20	....	I	C
480	J24c-4115	W. & H. F. Evans Greenhouse	Artesian Drlg.	1914	45	8	257 p	27	Pk	....	10	1914	10	....	U	....
486	J24c-3523	St. Elizabeth Convent	O'Donnell	....	75	8	400 p	....	Pk	....	....	....	90	....	D	....
487	J24c-3525	F. A. Simons Bros.	....	1947	45	....	....	....	Pk	....	....	....	......	....	D	....
493	J24c-3330	Badenhausen Corp.	O'Donnell	1920	35	8	505 p	....	Pk	....	30	10-2-46	20	<1	I	....
494	J24c-3730	Madsen Machine & Foundry	....	1915	30	8	260 p	....	Pk	....	8	10-2-46	......	....	I	....
495	J24c-3730	do.	....	1950	30	36	20 p	....	Qcm	20	....	....	......	....	I	....
496	J24c-3831	Pa. Salt Mfg. Co.	....	....	15	8	200 p	....	Pk	....	1	7-20-52	......	....	U	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
497	J24c-3733	Cornwall Chemical Corp.	Cook	1947	15	6	48 p	32	Pk	....	8	7-7-47	......	....	U	....
498	J24c-3132	Publicker Industries	Ridpath & Potter	1945	35	8	90 p	....	Pk	....	6	2-16-45	50	2	I	C
499	J24c-3634	do.	do.	1943	15	18-12	36 p	19	Qcm	34	11	7-8-43	......	52	....	C
500	J24c-3635	do.	....	....	15	17-12	32 f	....	Qcm	35	11	3-19-54	......	....	U	....
501	J24c-3533	do.	Ridpath & Potter	1947	15	6	144 p	48	Pk	....	6	12-6-47	......	<1	....	....
502	J24c-3232	do.	do.	1945	35	8	72 p	....	Pk	....	6	1-29-45	50	3	U	....
503	J24c-3337	Hill Crest Farms Dairy	....	....	15	6	265 p	....	Pk	....	14	10-2-46	10	....	D	....
504	J24c-3337	do.	....	1939	15	96	20 p	....	Qcm	20	6	1939	30	5	X	....
505	J24c-3337	do.	....	1943	15	120	24 p	....	Qcm	24	6	1943	50	5	I	....

506	J24c-3034	Eppinger & Russell Co.	Cook	1943	30	8	500 p	....	Pk	....	....	....	70	....	I	C
507	J24c-3034	do.	do.	1950	30	6	135 p	....	Pk	....	....	....	10	....	I	C
508	J24c-3035	do.	....	1946	35	6	35 p	....	Qcm	35	....	....	......	....	D	....
509	J24c-3035	E. A. Gerlach Co.	Cook	1946	35	4	68 p	....	Pk	....	....	....	......	....	I	C
510	J24c-2936	Phila. Bronze & Brass	....	....	30	....	....	....	......	....	....	....	......	....	....	....
520	J24c-3255	McKee Estate	....	....	15	6	41 p	....	Qcm	26	....	....	......	....	U	....
521	J24c-1963	Railway Specialties Corp.	....	....	25	....	....	....	Qcm	....	....	....	......	....	U	....
522	J24c-1963	do.	....	....	25	....	....	....	Qcm	....	....	....	......	....	D	....
525	J24b-7704	Bristol Aluminum Co.	Cook	1947	65	6	87 p	....	Pk	....	....	....	5	....	D	..
526	J24b-7703	do.	do.	1951	65	8	95 p	....	Pk	....	....	....	50	....	I	....
527	J24d-0105	Rex Engineering, Inc.	....	1950	30	36	14 p	....	Qcm	14	....	....	......	....	D	....
528	J24d-0301	Paul Harrigan & Sons	....	....	40	....	90 p	....	Pk	....	....	....	......	....	I	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location no.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
529	J24d-0402	Roadway Excavating Corp.	Cook	....	35	....	....	....	Pk	....	....	....	......	....	D	....
530	J24d-0500	Drum Co.	....	....	40	....	90 p	....	Pk	....	....	....	......	....	....	....
531	J24d-1604	Bristol Water Dept.	Artesian Drlg.	1942	20	16-12	70 p	42	Krs	17	8	1943	500	17	PS	C
532	J24d-1501	do.	do.	1942	20	16-12	65 p	32	Qcm	52	4	9-11-46	220	33	PS	P
533	J24d-1405	do.	do.	1942	20	16-12	85 p	40	Krs	20	....	....	480	....	PS	C
534	J24d-1502	do.	do.	1942	20	16-12	64 p	29	Qcm Krs	46	4	1943	500	25	PS	C
535	J24d-1602	do.	do.	1943	15	16-12	54 p	34	Qcm Krs	30	....	1946	170	....	PS	C
536	J24d-1602	do.	do.	1953	15	....	....	....	Qcm	20	....	....	......	....	U	....
537	J24d-1503	do.	do.	1944	25	16-12	74 p	38	Qcm	50	19	9-11-46	170	[illegible]	PS	C

538	J24d-1402	Bristol Water Dept.	Artesian Drlg.	1944	25	16-12	75 p	36	Qcm	23	....	....	170	....	PS	P
539	J24d-2002	Rohm & Haas	Layne-New York	1925	20	18	85 p	38	Kro	34	31	4-9-46	400	17	I	....
540	J24d-2104	do.	do.	1930	20	18	98 p	50	Krs	40	26	4-8-46	300	8	U	....
541	J24d-2203	do.	....	....	20	....	....	....	Kro Krs	20 5	....	....	......	....	I	....
542	J24d-1902	do.	Layne-New York	1934	20	18	110 p	70	Kro Krs	25 45	....	....	290	6	U	....
543	J24d-2203	do.	do.	1939	20	18	72 p	37	Kro Krs	19 5	25	4-17-46	390	26	U	....
544	J24d-2305	do.	do.	1939	20	18	65 p	54	Qcm Krs	33 17	11	4-4-46	950	27	U	....
545	J24d-2305	do.	do.	1941	20	18	56 p	36	Qcm Krs	4 8	11	4-4-46	1,050	30	U	....
546	J24d-2403	do.	do.	1942	15	16	56 p	36	Krs	18	14	4-10-46	770	24	U	....
547	J24d-2304	do.	....	1952	20	....	....	....	Qcm Krs	35 15	....	....	......	....	I	....
548	J24d-2109	Bristol Water Dept.	Lauman	1953	15	36-20	70 f	....	Qcm Kro	55	13	9-8-53	......	....	U	C
549	J24d-1510	Atlantic Ice Mfg. Co.	Harper	1910	20	8	40 p	30	Qcm	40	13	1910	70	....	U	....

TABLE 11.—RECORD OF WELLS, Continued

Well No	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
550	J24d-1411	Atlantic Ice Mfg. Co.	Harper	1910	20	8	86 p	60	Krs	18	13	1910	......	....	U	....
551	J24d-1510	do.	Artesian Drlg.	1942	20	12	98 p	88	Krs	20	30	9-18-46	150	10	U	C
552	J24d-1511	do.	Cook	1949	20	12	94 p	....	Krs	20	....	1952	150	....	I	....
553	J24d-1012	Kaiser Metal Products	....	....	25	96	22 p	....	Qcm	22	6	9-11-46	600	....	U	....
554	J24d-1011	do.	....	....	25	96	22 p	....	Qcm	22	6	9-11-46	500	....	U	....
555	J24d-1517	Manhattan Soap Co.	Artesian Drlg.	1941	25	12	50 p	40	Qcm	50	35	1946	200	....	I	....
556	J24d-0616	Hunter-Wilson Distilling Co.	do.	1939	30	16	60 p	40	Qcm	50	12	9-11-46	200	8	I	C
557	J24d-0718	Pacific Steel Boiler	....	....	25	72	22 p	....	Qcm	22	....	....	......	....	T	....
558	J24d-0619	Penn's Manor Inc.	....	....	25	168	30 p	....	Qcm	30	18	9-17-46	100	....	I	....

559	J24b-8124	L. D. Davis Co.	Artesian Drlg.	1936	20	8	45 p	45	Qcm	40	18	9-5-46	70	....	I	....
560	J24b-8124	do.	Ridpath & Potter	1943	20	8	41 p	27	Qcm	40	10	3-1-43	......	....	I	....
561	J24b-8124	do.	....	....	20	....	....	....	Qcm	40	....	....	......	....	....	....
562	J24b-8425	Bristol Water Dept.	Artesian Drlg.	1945	15	10	50 p	16	Qcm	21	....	....	300	44	PS	C
563	J24b-8425	do.	do.	1945	15	10	50 p	19	Qcm	21	....	....	400	44	PS	C
564	J24b-8324	do.	do.	1945	20	10	50 p	17	Qcm	40	14	2-23-45	250	....	U	....
565	J24b-8325	do.	do.	1945	15	10	50 p	25	Qcm	25	2	8-7-53	......	....	U	....
566	J24b-8425	do.	do.	1945	15	10	38 p 17 f	18	Qcm	32	3	8-7-53	......	....	U	....
567	J24b-8128	Paterson Parchment Co.	Layne-New York	1934	15	8-6	78 p	....	Krs	37	18	6-5-35	......	....	T	....
568	J24b-8129	do.	do.	1934	15	8-6	115 p	....	Krs	35	21	6-14-34	......	....	T	....
569	J24b-8227	do.	do.	1934	15	8-6	79 p	....	Krs	30	4	6-19-34	......	....	T	....
570	J24b-8227	do.	do.	1934	15	8-6	82 p	....	Krs	30	9	6-26-34	......	....	T	....

TABLE 11.—RECORD OF WELLS. Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
571	J24b-8028	Paterson Parchment Co.	Layne-New York	1934	15	8-6	92 p	....	Krs	30	4	7-3-34	......	....	T	....
572	J24b-8327	do.	do.	1934	15	44-26	33 p	23	Qcm	33	10	1934	350	50	A	....
584	J24b-6309	Hunter Mfg. Corp.	Artesian Drlg.	1942	110	8	157 p	32	Pk	....	40	9-5-46	120	....	U	....
585	J24b-6309	do.	....	1946	105	4	159 p	....	Pk	....	....	....	200	....	I	C
586	J24b-6015	Bell Telephone Co. of Pa.	Ridpath & Potter	1952	100	6	97 p	30	Pk	....	....	....	20	....	....	....
587	J24b-5321	Sand & Gravel Co.	Cook	....	40	....	....	....	Qcm	40	....	....	......	....	....	....
588	J24b-7234	Silvi Concrete Products	do.	1946	30	6	135 p	....	Pk	....	....	....	......	....	I	....
589	J24b-8130	Lower Bucks Co. Municipal Authority	Lauman	1951	8	12	40 p 27 f	26	Qcm	30	10	12-19-51	......	....	T	....
590	J24b-8130	do.	do.	1951	13	2	25 p	....	Qcm	36	....	....	......	....	T	....

591	J24b-8130	Lower Bucks Co. Municipal Authority	Lauman	1952	8	20	35 p	25	Qcm	36	....	....	......	....	PS	C
592	J24b-8230	do.	do.	1952	9	20	34 p	24	Qcm	35	....	....	......	....	PS	....
593	J24b-8230	do.	do.	1952	10	20	37 p	27	Qcm	38	....	....	......	....	PS	....
594	J24b-8230	do.	do.	1952	12	20	40 p	30	Qcm	41	....	....	......	....	PS	....
595	J24b-8230	do.	do.	1952	11	20	36 p	27	Qcm	38	....	....	725	....	PS	C
596	J24b-8130	do	do.	1953	15	....	....	....	Qcm	30	....	....	......	....	PS	....
597	J24b-8130	do.	do.	1952	9	6	30 p	....	Qcm	30	....	....	......	....	T	....
598	J24b-8130	do.	do.	1952	8	6	30 p	....	Qcm	30	....	....	......	....	T	....
599	J24b-8230	do.	do.	1952	13	2	25 p	....	Qcm	25	....	....	......	....	T	....
600	J24b-8230	do.	do.	1952	11	2	29 p	....	Qcm	29	....	....	......	....	T	....
601	J24b-8229	do.	do.	1952	8	2	20 p	....	Qcm	20	....	....	......	....	T	....
602	J24b-8230	do.	do.	1952	7	2	21 p	....	Qcm	21	....	....	......	....	T	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location no.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
603	J24b-7331	Levitt & Co.	....	....	25	....	....	....	Qcm Kro	55	....	....	......	....	A	....
604	J24b-7330	do.	....	1951	25	....	....	....	Qcm Kro	55	....	....	......	....	A	....
605	J24b-7231	do.	....	1951	25	....	....	....	Qcm Kro	55	....	....	......	....	A	....
606	J24b-4904	Falls Twp. Water & Sewer Authority	Cook	1951	140	6	75 p	....	Pk	....	....	....	40	....	PS	....
607	J24b-4804	do.	do.	1951	145	8	302 p	....	Pk	....	....	....	30	....	PS	....
608	J24b-4805	do.	do.	1951	145	8	113 p	....	Pk	....	....	....	40	....	PS	....
609	J24b-4317	do.	do.	1951	125	....	....	....	Pk	....	....	....	......	....	PS	....
610	J24b-4417	do.	do.	1951	125	....	....	....	Pk	....	....	....	10	....	PS	C
611	J24b-4617	do.	do.	1951	105	....	....	....	Pk	....	....	....	......	....	PS	....

612	J24b-4618	Falls Twp. Water & Sewage Authority	Cook	1951	105	....	....	....	Pk	....	....	....	20	....	PS	C
613	J24b-4129	Fallington Mfg. Co.	....	1949	85	4	70 p	....	Pk	....	....	....	......	....	D	....
614	J24b-4939	Amico Sand & Gravel Co.	Cook	1948	40	6	70 p	....	Qcm	55	....	....	......	....	D	....
615	J24b-4844	Pennsbury Pottery	....	1950	45	4	60 p	....	Qcm	60	....	....	......	....	I	....
616	J24b-4043	Falls Twp. Water & Sewer Authority	Cook	1952	45	6	102 p	....	Qcm	48	6	10-27-52	......	....	T	....
617	J24b-4143	do.	do.	1952	45	8	83 p	....	Qcm Krs	45 27	9	10-27-52	......	....	T	....
618	J24b-4143	do.	do.	1952	45	6	100 p	....	Qcm Krs	30 3	....	....	......	....	T	....
619	J24b-4142	do.	do.	1952	45	6	100 p	....	Qcm Krs	57 24	....	....	......	....	T	....
620	J24b-4143	do.	do.	1953	45	....	100 p	....	Qcm Krs	57 24	....	....	700	....	PS	C
621	J24b-3147	Bucks Co. Farms Dairies	....	1930	55	6	80 p	....	Pk	....	....	....	10	....	I	C
622	J24b-3147	do.	....	1944	55	6	160 p	....	Pk	....	....	....	20	....	I	....
623	J24b-2951	Consumers Ice Co.	....	1915	40	6	30 p	....	Qcm	30	....	....	20	....	U	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location no.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer		Water level		Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
									Formation	Thickness (feet)	Depth below land surface (feet)	Date of measurement				
624	J24b-2952	Vulcanized Rubber & Plastics Co.	Harper	1903	30	8	716 p	35	Pk	....	18	1946	......	....	U	....
625	J24b-3354	Morrisville Water Dept.	Layne-New York	1935	20	8	74 p	....	Qcm Krs	26 10	27	10-10-35	......	....	T	....
626	J24b-3656	do.	do.	1937	21	8	146 p	....	Qcm Krs	32 10	11	1-7-37	280	......	T	....
627	J24b-3957	do.	do.	1937	21	10-6	117 p	....	Krs Krf	56 20	19	2-27-37	......	....	T	....
628	J24b-3957	Morrisville Water Dept.	Layne-New York	1951	25	24-10	175 p	139	Krf	25	22	1951	700	28	U	....
629	J24b-4060	Victor Chemical Works	do.	1948	18	16-10	170 p	....	Krf	38	10	3-31-48	100	20	I	C
630	J24b-3950	King Supply Co.	Ridpath & Potter	1951	25	6	40 p	30	Qcm	40	16	1951	......	....	....	....
631	J24b-4149	Cartex Corp.	....	....	25	6	40 p	....	Qcm	40	....	....	......	....	I	....
632	J24b-5544	Warner Co.	Philadelphia Drlg.	1951	25	6	31 p	24	Qcm Kro	31	6	1951	10	....	I	....

633	J24b-6751	King Farms Co.	Artesian Drlg.	1929	20	12	70 p	70	Krs	47	11	5-4-50	90	....	U	....
634	J24b-6751	do.	Stothoff	1944	21	12	58 p	48	Krs	10	....	....	300	....	I	C
635	J24b-7146	do.	do.	1944	20	12	55 p	42	Krs	13	10	1944	90	....	D	....
636	J24b-6750	do.	Ridpath & Potter	1950	20	12	67 p	58	Krs	13	15	1-50	170	....	I	C
637	J24b-6058	U. S. Steel	Bainbridge	1947	20	8	25 p	15	Qcm	25	10	4-47	......	....	I	....
638	J24b-8056	Pennsbury Manor	....	....	15	6	90 p	....	Qcm	55	16	6-13-50	50	....	D,Irr	C
639	J24b-6865	U. S. Steel	....	....	25	....	25 p	....	Qcm	25	....	....	......	....	D	C
640	J24b-7863	do.	....	....	15	....	20 p	....	Qcm	20	....	....	......	....	D	C
641	J25a-7603	do.	....	....	15	....	20 p	....	Qcm	20	....	....	......	....	D	C
642	J25a-7304	do.	....	....	15	....	20 p	....	Qcm	20	....	....	......	....	D	C
643	J25a-6907	do.	....	....	15	....	20 p	....	Qcm	20	....	....	......	....	D	C
644	J25a-6313	do.	....	....	15	....	20 p	....	Qcm	20	....	....	......	....	D	C

TABLE 11.—RECORD OF WELLS. Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
645	J25a-6704	U. S. Steel	-------	1926	20	8	40 p	40	Qcm	40	13	5-25-50	600	....	I	C
646	J25a-6706	do.	-------	1942	15	8	30 p	30	Qcm	30	23	1946	600	....	I	....
647	J25a-5506	do.	-------	1944	15	6-4	51 f	33	Qcm	53	10	10-20-44	100	20	U	P
648	J24b-5962	do.	-------	1950	20	4	199 p	65	Kro	20	15	3-15-51	......	....	T	....
649	J24b-5565	do.	-------	1951	26	12	45 p	....	Qcm	45	18	7-17-53	......	....	T	....
650	J25a-5710	do.	Ranney	-------	13	12	48 p	....	Qcm	85	16	7-17-53	......	....	T,U	....
651	J25a-5610	do.	do.	1952	7	....	50 p	....	Qcm Kro	50	....	....	7,000	....	I	C
652	J25a-6213	do.	do.	1952	15	....	60 p	....	Qcm Kro	60	....	....	7,000	....	I	C
653	J25a-6513	do.	do.	1952	4	....	36 p	....	Qcm	36	....	....	4,000	....	I	....

654	J24b-4660	Philadelphia Electric Co.	Artesian Drlg.	1951	20	6	71 p	60	Kro	17	15	9-51	......	3	I	....
666	J24c-4015	Mack Transportation Co.	....	1930	50	8	219 f	....	Pk	....	18	5-19-53	......	....	T	....
668	J24c-3132	Publicker Industries	Ridpath & Potter	1945	....	8	223 p	....	Pk	....	....	....	......	<1	X	....
669	J24c-3132	do.	do.	1945	....	8	174 p	....	Pk	....	11	1-24-45	......	2	....	....
670	J25a-5609	U. S. Steel	....	....	....	6	40 f	....	Qcm	75	18	7-17-53	......	....	I	C
671	J24b-8156	Pennsbury Manor	....	1700	10	24-32	17 f	....	Qcm	55	14	7-28-53	......	....	U	....
672	J24c-3354	A. C. Smith	....	....	10	36	11 f	....	Qcm	30	4	8-12-53	10	....	D	C
673	J24c-4125	Pen Ryn Episcopal School	....	1900	....	48	25 f	....	Qcm	25	14	12-1-53	......	....	PS	C
674	J24c-3253	A. C. Smith	....	....	15	30	....	....	Qcm	30	....	....	......	....	D	....
676	J25a-6613	U. S. Steel	Ranney	1955	8	6	213 p	....	....	....	....	....	......	....	T	....
678	J25a-6610	do.	do.	1955	7	6	137 p	....	....	....	....	....	......	....	T	....
679	J25a-6408	do.	do.	1956	5	....	114 p	....	....	....	....	....	......	....	T	....

TABLE 11.—RECORD OF WELLS, Continued

Well No.	Location No.	Owner	Driller	Date completed	Altitude (feet)	Diameter (inches)	Depth of well (feet)	Depth of casing (feet)	Aquifer: Formation	Aquifer: Thickness (feet)	Water level: Depth below land surface (feet)	Water level: Date of measurement	Yield (gpm)	Specific capacity (gpm per foot of drawdown)	Use	Chemical analysis
680	J25a-6403	U. S. Steel	Ranney	1955	14	6	157 p	....	....	....	....	....	......	....	T	....
681	J25a-5909	do.	do.	1955	14	6	201 p	....	....	....	....	....	......	50	T	....
682	J25a-5307	do.	do.	1955	14	6	146 p	....	....	....	....	....	......	....	T	....
683	J25a-5605	do.	do.	1955	14	6	155 p	....	....	....	....	....	......	....	T	....
688	J24d-2007	Bristol Water Dept.	....	1954	10	....	....	....	....	....	....	....	......	....	T	C
689	J24b-4660	U. S. Steel	....	1955	20	6	61 p	51	Kro	10	....	....	70	....	I	C
690	J24b-6758	do.	....	1955	18	6	80 p	68	Kro	12	....	....	......	....	I	C
691	J24b-8229	Lower Bucks Co. Joint Municipal Water & Sewer Authority	....	....	10	....	40 p	....	Qcm	40	....	....	700	....	PS	C

729	J24b-7763	U. S. Steel	--------	1949	12	8	96 p	----	--------	----	----	------------	------	----	T	----
730	J25a-6312	do.	--------	1949	14	8	100 p	----	--------	----	----	------------	------	----	T	----
731	J25a-5902	do.	--------	1949	8	8	181 p	----	--------	----	----	------------	------	----	T	----
732	J25a-7307	do.	-------	1949	8	8	100 p	----	--------	----	----	------------	------	----	T	----
733	J25a-5408	do.	--------	1949	14	8	102 p	----	--------	----	----	------------	------	----	T	----
734	J24b-6561	do.	------ -	1949	12	8	106 p	----	--------	----	----	------------	------	----	T	----

TABLE 12—CHEMICAL ANALYSES OF GROUND WATER IN THE COASTAL PLAIN AREA, SOUTHEASTERN PENNSYLVANIA

(Analyses by Quality of Water Branch, U. S. Geological Survey except as indicated. Results in parts per million except as indicated)

	Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
PHILADELPHIA COUNTY																		
	1	4- 8-43	....	23	0.2	6.6	0.9	31	85	14	17	....	0	129	....	....	....	6.9
	1	7-19-43	....	23	.25	7.4	4.6	26	90	10	19	....	.44	129	....	....	....	7.3
a/	1	1-14-44	....	19	.2	12	4.0	23	98	5.6	15	....	0	129	....	....	....	6.6
a/	1	2-15-44	....	28	.10	7.5	3.2	38	104	6.4	17	....	.44	124	....	....	....	6.5
a/	1	6-19-44	....	12	.38	6.1	1.6	38	92	10	22	....	.44	139	....	....	....	7.0
a/	1	10- 3-44	....	3.0	.1	13	4.1	19	85	7.0	19	....	.48	134	....	....	....	6.4

1	11-15-45	56	14	1.2	17	7.7	24	4.1	118	10	15	0.3	2.0	148	....	....	265	6.6
1	12-13-45	56	....	....	....	....	....	....	117	....	17	....	2.4	....	....	....	258	6.3
1	1- 3-46	56	....	....	....	....	....	....	118	....	16	....	2.4	....	76	....	264	6.3
1	1-17-46	....	....	....	....	....	....	....	120	....	18	....	3.0	....	72	....	270	6.3
1	1-31-46	57	....	....	....	....	....	....	120	....	18	....	2.7	....	....	75	267	6.4
1	2-14-46	57	....	1.3	....	....	....	....	122	15	14	....	2.7	....	78	....	270	6.4
1	2-28-46	56	....	....	....	....	....	....	118	....	18	....	3.1	....	....	....	271	6.4
1	3-14-46	57	....	1.5	....	....	....	....	120	13	19	....	2.9	....	81	....	275	6.4
1	3-28-46	57	....	1.7	....	....	....	....	126	12	19	....	3.7	....	84	....	280	6.3
1	4-11-46	57	....	1.5	....	....	....	....	124	14	19	....	3.9	....	80	....	286	6.2

a/ Chemical analysis by U.S. Navy

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH
1	4-25-46	56	....	1.5	....	....	....	....	125	13	17	....	3.6	....	81	....	283	6.3
1	5- 9-46	57	....	1.3	....	....	....	....	124	15	18	....	3.4	....	81	....	284	6.4
1	6-20-46	56	....	1.3	....	....	....	....	122	11	18	....	3.7	....	81	....	285	6.5
1	7-11-46	56	....	.20	....	....	....	....	123	14	18	....	3.2	....	87	....	285	6.7
1	7-26-46	57	....	.20	....	....	....	....	122	20	18	....	4.0	....	78	....	290	6.5
1	8-15-46	56	....	2.0	21	8.8	24	2.9	122	12	16	0.3	4.2	162	89	....	293	6.8
1	8-29-46	57	....	....	....	....	....	....	130	22	18	....	5.1	....	100	....	290	6.4
1	9-12-46	57	....	....	....	....	....	....	130	16	17	....	2.8	....	100	....	294	6.6
1	10-10-46	57	....	....	19	8.3	....	....	120	14	18	....	7.0	....	82	....	290	6.3

	1	12- 5-46	57	....	....	....	....	....	....	120	18	18	....	5.7	....	88	....	295	6.3
a/	1	1-30-47	....	14	2.0	17	7.9		31	120	18	24	....	.02	192	....	....	....	5.9
	1	2-27-47	....	....	....	....	....	....	....	123	16	20	....	6.1	....	99	....	295	6.3
a/	1	2-28-47	....	19	2.1	25	9.5		21	122	20	24	....	.1	177	....	....	....	6.1
a/	1	3-31-47	....	17	2.7	27	9.7		13	112	16	28	....	.01	200	....	....	....	5.9
a/	1	5- 2-47	....	17	2.8	26	9.6		11	117	13	28	....	.0	194	....	....	....	5.9
a/	1	6- 5-47	....	17	1.7	26	9.6		17	120	20	28	....	.04	188	....	....	....	6.0
a/	1	7- 7-47	....	15	2.0	25	10		17	112	19	27	....	.04	173	....	....	....	5.9
a/	1	9- 5-47	....	36	2.2	16	9.2		16	.....	20	26	....	.0	196	....	....	....	5.9
a/	1	10- 2-47	....	15	3.2	27	8.9		0	115	18	28	....	.04	200	....	....	....	5.9

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
a/ 1	1- 9-48	....	19	2.1	22	9	0		120	22	24	....	0.10	193	....	....	....	6.3
1	7-28-49	....	20	4.0	32	12	27		112	38	36	....	.08	256	....	....	....	6.2
1	4-25-49	57	16	6.2	32	13	25	5.0	110	42	31	0.2	12	238	133	43	238	6.0
a/ 1	2-18-49	....	16	.56	29	12	26		120	40	35	....	.14	225	....	....	....	6.2
a/ 1	10- 8-48	....	16	3.7	28	12	25		113	34	32	....	10	225	....	....	....	6.2
1	10-27-49	....	15	3.0	39	13	19		116	48	35	....	.13	228	87	....	....	6.2
1	12-23-53	57	....	5.0	....	....	27		93	142	46	....	6.1	....	236	160	689	6.0
1	2-19-54	57	16	5.9	54	23	38	6.0	160	124	57	.2	4.1	406	152	152	653	6.5
1	4-12-54	58	....	....	....	....	....	....	100	159	62	....	....	....	240	....	681	6.3

	1	10- 8-54	57	....	5.4	....	....		25		96	116	69	....	5.5	....	246	167	723	6.2
	1	1-17-56	....	18	2.3	62	33		13		351	174	65	.4	3.3	511	290	3	801	6.8
	1	7-23-57	57	16	3.8	68	31	50		5.8	158	181	59	.4	4.9	559	297	168	827	6.1
	2	4- 8-43	....	18	.2	7.7	2.3		34		92	8.8	20	....	0	155	....	....	....	7.0
a/	2	7-19-43	....	18	.20	17	4.4		26		104	13	22	....	.44	145	....	....	....	7.4
a/	2	1-14-44	....	16	.3	12	3.4		42		122	9.9	22	....	0	142	....	....	....	6.7
a/	2	2-15-44	....	38	.49	8.5	1.6		45		104	11	26	....	.44	141	....	....	....	6.7
a/	2	6-19-44	....	18	.38	12	3.7		35		110	12	25	....	.13	162	....	....	....	7.3
	2	11-15-45	57	11	.47	15	5.9	32		4.1	122	11	18	.5	.1	156	62	....	274	6.7
	2	12-13-45	57	....	....	....	....	....		....	121	....	18	....	0.8	....	....	....	271	6.5

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$ Calcium, magnesium	Hardness as $CaCO_3$ Non-carbonate	Specific conductance (micromhos at 25°C)	pH
2	1-17-46	....	....	....	....	....	....	....	124	....	18	....	.8	....	....	....	278	6.5
2	1-31-46	57	....	....	....	....	....	....	126	....	19	....	.1	....	....	....	176	6.7
2	3-14-46	58	....	0.20	....	....	....	....	131	14	20	....	.1	....	72	....	280	6.7
2	3-28-46	57	....	....	....	....	....	....	127	12	21	....	1.0	....	69	....	281	6.6
2	4-11-46	57	....	....	....	....	....	....	127	12	18	....	1.0	....	66	....	281	6.5
2	4-25-46	57	....	....	....	....	....	....	127	12	19	....	1.3	....	68	....	283	6.6
2	5- 9-46	57	....	.43	....	....	....	....	130	14	18	....	.7	....	64	....	289	6.7
2	6-20-46	57	....	1.2	....	....	....	....	130	12	20	....	1.0	....	69	....	288	6.8
2	7-11-46	58	....	.10	....	....	....	....	126	15	18	....	.9	....	74	....	285	6.8

	2	7-26-46	58	....	....	... .	....	....		. ...	126	13	19	....	1.2	....	68	....	288	6.8
	2	8-15-46	57	11	.68	17	6.7	33		2.4	127	9.9	20	0.5	1.1	159	70	....	285	7.0
	2	9-12-46	57	....	....	....	....	....		....	130	10	18	....	1.0	....	76	....	285	6.8
	2	12- 5-46	....	....	....	....	....	....		....	126	5.8	18	....	1.0	....	74	....	281	6.6
	2	1-16-47	58	....	....	....	....	....		....	126	....	....	....	....	....	....	....	280	6.6
	2	2-27-47	57	....	....	....	....	....		....	132	9.1	17	....	.2	....	76	....	275	6.6
	2	3-13-47	57	....	....	....	....	....		....	132	....	....	....	....	....	....	....	277	6.5
	2	3-27-47	58	....	....	....	....	....		....	132	....	....	....	....	....	....	....	282	6.6
a/	2	9- 5-47	....	12	1.0	18	8.9		30		135	8.2	24	....	0.0	168	....	....	....	6.3
a/	2	5- 2-47	....	20	1.0	26	6.6		.0		62	8	22	....	.0	168	....	....	....	6.3

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
a/ 2	6-14-48	....	10	1.8	18	2.0		43	130	10	20	....	.20	179	....	....	....	6.3
2	4-25-49	57	12	4.0	20	8.0	28	3.6	133	13	18	0.3	3.7	174	83	....	305	6.9
2	4-27-50	....	14	3.9	20	10	....	....	159	28	30	....	trace	216	....	....	....	6.4
a/ 2	10-27-50	....	10	5.6	26	13		41	183	20	26	....	.00	225	108	....	....	6.4
a/ 2	2-28-51	....	6	7.8	25	14		36	172	17	29	....	.08	245	102	....	....	6.4
a/ 2	12-20-51	....	9	4.9	32	15		26	146	26	36	....	....	275	130	....	....	6.0
a/ 2	2-28-52	....	10	5.4	27	15	....	....	120	29	35	....	....	240	108	....	....	6.0
a/ 2	4-29-53	....	10	5.3	....	....	....	....	196	66	30	....	....	....	160	....	....	6.1
a/ 2	4-12-54	....	10	2.9	41	28		32	166	75	51	....	....	....	216	....	....	6.0

a/	3	4-13-43	....	10	.07	5.7	1.1		34		79	9.7	20	....	0	121	....	....	....	6.8
a/	3	2-15-44	....	25	0	6.0	1.0		39		79	4.9	24	....	3.3	125	....	....	....	6.5
a/	3	10- 3-44	....	2.2	.07	11	3.3		28		79	11	26	....	.48	140	....	....	....	6.4
	3	11-15-45	57	15	.02	14	5.9	25		3.6	76	12	21	.3	12	148	59	....	252	6.3
	3	12-13-45	56	....	....	....	....	....		....	82	....	23	....	14	....	....	....	262	6.2
	3	1- 3-46	57	....	....	....	....	....		....	80	....	23	....	14	....	68	....	264	6.2
a/	3	1-10-46	....	19	.1	15	6.2		25		88	12	27	....	.22	158	....	....	....	6.1
	3	2-14-46	57	....	0.1	....	....	....		....	86	15	25	....	13	....	64	....	272	6.3
	3	3-14-46	58	....	.1	....	....	....		....	85	15	26	....	12	....	72	....	269	6.4
	3	4-25-46	57	....	.10	....	....	....		....	83	14	24	....	15	....	63	....	276	6.3

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH
3	5- 9-46	56	....	.1	....	....	....	....	82	16	23	....	12	....	68	....	279	6.4
3	6-20-46	57	....	.16	....	....	....	....	80	15	26	....	18	....	75	....	285	6.5
3	7-11-46	58	....	....	....	....	....	....	84	19	25	....	16	....	80	....	290	6.6
3	9-12-46	58	....	....	....	....	....	....	86	21	25	....	9.1	....	90	....	309	6.4
3	9-26-46	57	....	....	....	....	....	....	86	21	26	....	8.2	....	99	....	309	6.2
3	10-10-46	57	....	....	....	....	....	....	94	29	26	....	18	....	92	....	314	6.3
3	12- 5-46	58	....	....	....	....	....	....	106	25	26	....	20	....	102	....	334	6.3
3	1-16-47	57	....	....	....	....	....	....	107	....	....	....	....	....	....	....	338	6.3
3	2-27-47	56	....	....	....	....	....	....	112	20	26	....	15	....	103	....	336	6.2

	3	3-13-47	57	--------	--------	--------	--------	--------		--------	110	--------	--------	--------	--------	--------	--------	--------	336	6.2
a/	3	5- 2-47	....	16	.03	27	9.8		17		109	13	32	--------	.07	208	--------	--------	--------	5.9
a/	3	6- 5-47	....	16	.1	27	9.1		24		117	23	32	--------	.09	212	--------	--------	--------	5.9
a/	3	7- 7-47	....	15	.1	29	10		24		124	21	33	--------	.09	196	--------	--------	--------	6.1
a/	3	10-30-47	....	14	.0	26	11		25		124	21	28	--------	.02	244	--------	--------	--------	6.1
a/	3	11- 5-48	....	16	.28	30	14		24		144	25	28	--------	.15	229	--------	--------	--------	6.3
a/	3	12-13-48	....	14	0.28	30	14		24		138	26	30	--------	0.20	224	--------	--------	--------	6.4
	3	4-25-49	57	15	1.0	32	14	27		5.9	146	30	27	0.2	11	254	137	18	402	6.2
a/	3	8-25-49	....	12	.20	33	11		24		134	28	30	--------	.2	265	129	--------	--------	6.4
a/	3	10-27-49	....	16	.21	30	10		39		148	30	30	--------	.18	288	110	--------	--------	6.4

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.--CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
a/ 3	2-23-50	....	10	.20	34	18		18	136	38	34	....	.07	250	144	....	....	6.4
a/ 3	11- -50	....	10	.21	36	19	....	....	117	56	35	....	.01	249	156	....	....	6.3
a/ 3	2-28-51	....	7.5	.42	30	18		31	138	50	38	....	.19	221	140	....	....	6.0
a/ 3	11-26-51	....	9	.63	36	19		13	134	41	31	....	....	200	179	....	....	6.3
a/ 3	2-28-52	....	12	.91	35	20		12	130	46	30	....	....	198	188	....	....	6.2
a/ 3	5-28-52	....	11	1.0	37	20		12	122	43	39	....	....	....	252	....	....	6.3
a/ 3	4-12-54	....	11	.91	44	25		14	183	44	34	....	....	....	216	....	....	6.2
3	1-17-56	....	15	5.8	41	15		36	155	59	27	.4	19	292	164	36	491	8.3
3	7-23-57	59	14	11	40	16	26	4.7	157	55	25	.6	13	294	166	38	480	6.3

a/	4	4-13-43	....	15	.21	5.0	1.9		36		85	9.7	24	....	0	133	....	....	....	6.9
	4	11-15-45	57	17	.48	11	4.4	25		3.8	72	20	13	.2	4.8	135	46	....	219	6.2
	4	12-13-45	57	....	....	....	....	....		....	77	....	15	....	6.0	....	....	....	224	6.1
	4	1-17-46	....	....	....	....	....	....		....	76	....	16	....	5.5	....	54	....	227	6.1
	4	2-14-46	57	....	....	....	....	....		....	80	27	16	....	4.9	....	56	....	232	6.2
	4	3-28-46	58	....	....	....	....	....		....	73	27	17	....	7.1	....	50	....	232	6.1
	4	4-11-46	58	....	....	....	....	....		....	77	27	14	....	6.0	....	52	....	238	6.1
a/	4	4-12-46	....	11	0.6	13	5.2		27		87	22	17	....	.54	147	....	--	....	5.9
	4	5- 9-46	57	....	.42	....	....	....		....	73	29	11	....	5.5	....	57	....	237	6.2
	4	6-20-46	....	....	.12	....	....	....		....	75	25	16	....	5.3	....	56	....	239	6.3

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
4	7-11-46	58	....	....	....	....	....	....	76	30	14	....	4.9	....	58	....	241	6.5
4	8-15-46	58	15	.64	15	5.6	25	2.5	84	23	15	0.2	5.0	152	60	....	253	6.7
4	9-26-46	58	....	....	....	....	....	....	86	29	16	....	6.6	....	72	....	252	6.2
4	12- 5-46	58	....	....	....	....	....	....	93	24	14	....	5.4	....	78	....	268	6.3
a/ 4	1-30-47	....	16.	.6	18	6.6	26		105	22	18	....	.0	184	....	....	....	5.9
4	2-27-47	60	....	....	....	....	....	....	102	24	17	....	5.8	....	76	....	275	6.2
a/ 4	7- 7-47	....	15	.63	22	7	18		100	22	25	....	.04	172	....	....	....	5.9
a/ 4	5- 7-48	....	15	1.5	24	10	33		126	20	24	....	.10	224	....	....	....	5.9
a/ 4	10- 8-48	....	15	1.5	26	11	25		123	21	26	....	10	212	....	....	....	....

	4	4-26-49	....	16	1.1	28	11	24		3.8	115	26	22	.2	17	217	115	21	351	6.5
	4	2-23-50	....	9	2.9	28	20		19		131	34	28	....	.06	240	154	....	....	6.4
a/	4	12-28-50	....	17	1.2	24	19		40		172	61	32	....	.23	176	....	....	....	6.0
a/	4	3-30-51	....	13	.48	35	20		17		107	59	40	....	1.4	236	178	....	....	6.1
a/	4	12-20-51	....	10	0.91	32	19		22		120	51	38	....	....	200	184	....	....	6.2
a/	4	2-28-52	....	10	.84	38	19	....		....	135	52	40	....	....	200	160	....	....	6.3
a/	4	4-12-54	....	12	2.3	45	24		22		190	50	37	....	....	....	212	....	....	6.3
	4	7-23-57	59	13	12	40	16	22		4.9	174	45	17	0.6	11	280	166	24	460	6.2
a/	5	9-30-42	....	16	....	5.0	3.5		51		122	2.8	31	....	0	160	....	....	....	....
	5	11-16-43	....	15	7.0	19	10		8.2		183	6.0	19	....	.2	189	....	....	....	6.7

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

	Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
																Calcium, magnesium	Non-carbonate		
	5	10- 8-54	57	7.6	5.9	45	16		9.8	146	2.0	17	.8	64	293	178	58	469	8.2
a/	6	6-19-44	....	25	.86	23	7.3		9.1	79	69	19	....	9.3	247	....	....	....	6.0
	6	5-23-46	56	....	....	....	....	....	....	86	....	21	....	....	....	....	....	411	6.1
	6	8-15-46	56	17	.05	32	18	16	3.1	66	96	18	.1	8.2	255	154	....	391	6.4
	6	4-25-49	56	19	.50	31	18	17	5.0	82	83	18	.1	13	264	151	84	393	6.5
a/	6	7-25-50	....	10	0	10	22	....	....	139	85	48	....	10	....	190	....	....	7.0
	6	7-23-57	58	13	12	50	27	18	5.4	162	115	16	.5	17	381	248	0	582	6.1
a/	7	2-15-44	....	25	.61	9.1	.91		37	85	12	19	....	1.1	122	....	....	....	5.1
a/	7	10- 3-44	....	3.4	.98	8.3	1.9		26	79	12	19	....	.62	129	....	....	....	7.2

7	11-15-45	58	8.8	.82	8.3	2.1	30	4.2	85	14	12	.5	.1	122	29	....	206	7.2
7	12-13-45	58	....	....	....	....	....	....	83	....	13	....	.0	....	....	....	204	7.0
7	1-17-46	....	....	.68	....	....	....	....	86	....	13	....	.1	....	36	....	206	7.1
7	2-14-46	58	....	0.60	....	....	....	....	86	14	14	....	0.1	....	33	....	204	7.4
7	3-14-46	58	....	.52	....	....	....	....	85	16	14	....	.2	....	33	....	203	7.2
7	3-28-46	58	....	.48	....	....	....	....	86	17	15	....	.1	....	28	....	207	7.0
7	4-11-46	58	....	.60	....	....	....	....	85	16	12	....	....	....	32	....	206	7.2
7	5- 9-46	58	....	.62	....	....	....	....	84	23	13	....	.0	. .	34	....	207	7.2
7	6-20-46	58	....	.52	....	....	....	....	84	19	13	....	.4	..	32	....	205	7.2
7	7-11-46	58	....	.68	....	....	....	....	84	18	12	....	.1		28	....	204	7.2

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
7	7-26-46	58	....	.60	....	....	....	....	84	23	12	....	.1	....	32	....	207	7.2
7	8-15-46	58	9.5	.70	8.7	2.2	30	2.9	82	13	12	0.5	.1	122	32	....	205	7.4
a/ 7	9- 3-46	....	12	.5	8.8	1.7	32		79	15	16	....	.0	126	....	....	....	7.0
7	10-10-46	57	....	....	....	....	....	....	87	16	11	....	.1	....	33	....	204	7.2
a/ 7	11- 4-46	....	18	.8	7.1	2.8	35		84	15	16	....	.0	121	....	....	....	7.0
7	12- 5-46	58	....	....	....	....	....	....	86	13	11	....	.1	....	36	....	204	7.2
a/ 7	1-30-47	....	12	.8	8.8	1.3	31		77	15	14	....	.0	132	....	....	....	6.7
a/ 7	2-28-47	....	16	.91	8.7	3.4	31		82	16	16	....	.02	129	....	....	....	7.1
a/ 7	7- 7-47	....	14	.77	10	2	29		85	15	18	....	.0	98	....	....	....	7.1

a/	7	5- 7-48	....	12	.98	8.2	2.3		33		86	16	12	-------	.10	166	-------	-------	-------	7.1
	7	4-25-49	58	9.5	.83	8.2	2.1	29		3.5	82	14	12	.2	1.0	124	29	-------	203	7.2
	7	8-25-49	....	10	1.0	16	8		21		99	16	18	-------	0.1	124	104	-------	-------	7.2
	7	3-23-50	....	14	.70	16	8		23		89	12	18	-------	.12	120	35	-------	-------	7.2
	7	12-28-50	....	12	1.9	9	9.7	-------		-------	92	17	19	-------	.09	122	-------	-------	-------	7.2
	7	1-30-51	....	7.0	.30	12	7.1	-------		-------	93	14	22	-------	.24	175	54	-------	-------	7.2
a/	7	10-30-51	....	10	.98	20	8	-------		-------	85	19	20	-------	.35	180	61	-------	-------	7.1
a/	7	2-28-52	....	10	1.0	21	10		22		85	21	35	-------	-------	160	52	-------	-------	7.1
a/	7	5-28-52	....	9	.94	10	8	-------		-------	86	26	24	-------	-------	-------	38	-------	-------	7.1
a/	7	4-29-53	....	9	5.5	-------	-------	-------		-------	53	18	14	-------	-------	-------	44	-------	-------	7.3

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH
a/ 7	4-12-54	....	9	1.3	17	29		8.9	142	43	47	....	....	....	166	....	....	6.9
7	1-17-56	....	10	1.7	10	2.3		31	84	13	12	0.3	.9	127	34	0	208	7.8
8	10-27-44	....	30	.42	6.4	3.2		33	95	16	32	....	.09	195	....	....	....	7.3
8	11- 1-44	....	14	.42	7.9	2.4		33	92	11	34	....	.27	163	....	....	....	7.6
8	11-15-45	58	8.6	.81	6.0	1.9	50	2.9	96	9.1	32	.8	.1	163	23	....	285	7.3
8	12-13-45	58	....	....	....	....	....	....	102	....	33	....	.4	....	....	....	286	7.0
8	1-17-46	....	....	.80	....	....	....	....	97	....	34	....	.6	....	24	....	285	7.2
8	2-14-46	58	....	.72	....	....		57	102	14	35	....	.1	....	24	....	286	7.3
8	3-14-46	58	....	.80	....	....	....	....	102	11	36	....	.1	....	22	....	287	7.3

	8	3-28-46	58	....	.48	....	....	....		....	100	13	36	....	.6	....	24	....	289	6.9
	8	4-11-46	58	....	0.72	....	....		54		102	11	33	....	....	....	24	....	288	7.1
	8	4-25-46	58	....	.80	....	....	....		....	102	11	33	....	0.2	....	26	....	288	7.1
	8	5- 9-46	58	....	.64	....	....	....		....	101	13	34	....	.0	....	24	....	292	7.1
	8	6-20-46	58	....	.52	....	....		55		104	11	33	....	.2	....	24	....	288	7.3
	8	7-11-46	....	....	.72	....	....		56		102	14	33	....	.5	....	24	....	288	7.3
	8	8-15-46	58	8.9	1.0	7.2	1.8	51		2.1	102	7.7	32	0.8	.1	165	25	....	288	7.6
	8	9-12-46	58	....	....	....	....	....		....	104	10	30	....	....	....	30	....	290	7.3
	8	10-24-46	58	....	....	....	....	....		....	104	....	....	....	....	....	....	....	290	7.3
a/	8	11- 4-46	....	7.0	.84	5.5	.7		52		99	10	35	....	0	174	....	....	....	7.1

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH
a/ 8	12-30-46	....	21	1.0	4.4	4.6	49		102	4.9	38	....	0	164	....	....	....	7.1
a/ 8	1-30-47	....	7.0	.35	7.4	.9	54		105	7.9	36	....	0	172	....	....	....	7.1
a/ 8	2-28-47	....	13	.35	6.2	2.6	52		105	7.1	36	....	.01	159	....	....	....	7.1
8	3-27-47	64	....	....	....	....	....	....	102	....	....	....	....	....	....	....	286	7.3
a/ 8	7- 7-47	....	9	.91	7	2	52		101	8	37	....	0	157	....	....	....	7.1
a/ 8	7- 9-48	....	10	.98	7.4	1.9	51		98	7.7	30	....	.01	180	....	....	....	....
a/ 8	11- 5-48	....	8.8	2.4	6.0	1.9	50		99	6.6	34	....	.08	167	....	....	....	7.1
8	4-25-49	58	10	1.0	7.0	2.2	48	3.0	106	8.5	30	.4	1.0	167	26	....	288	7.2
a/ 8	6-30-49	....	8	1.3	7	2	50		101	10	34	....	13	165	....	....	....	7.1

a/	8	7-28-49	....	8	1.3	9	2.5		54		101	10	37	....	0.10	169	....	....	....	7.3
	8	8-25-49	....	10	1.0	9	2		27		105	6	36	....	.14	165	61	....	....	7.1
	8	10-27-49	....	10	.77	10	3		38		110	11	36	....	.14	216	60	....	....	7.2
	8	12-29-49	....	8	.98	12	4		37		110	14	37	....	.13	225	76	....	....	7.2
	8	1-19-50	....	10	2.0	10	3	....		....	132	12	34	....	.00	166	65	....	....	7.2
	8	2-23-50	....	12	1.4	7.3	3.3		42		107	12	42	....	.1	168	50	....	....	7.0
	8	3-23-50	....	10	1.1	9	2		38		106	11	37	....	.11	180	26	....	....	7.2
	8	4-27-50	....	10	2.0	10	3		61		132	12	34	....	.00	166	....	....	....	7.2
a/	8	5-18-50	....	....	1.1	....	....	....		....	....	10	....	....	....	....	....	....	....	7.2
a/	8	11- -50	....	9	2.6	7	7	....		....	134	15	35	....	.10	220	42	....	....	7.0

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH
8	12-28-50	....	12	2.2	7.2	5.3	....	....	109	16	41	....	.16	262	40	....	....	7.0
8	1-30-51	....	9	3.4	8	6.4	....	....	102	21	34	....	.10	235	42	....	....	7.1
8	3-30-51	....	6.8	3.7	18	7.7		49	140	17	36	....	.42	230	76	....	....	6.8
a/ 8	10-30-51	....	8	3.6	16	10	....	....	128	29	33	....	.2	260	81	....	....	6.7
a/ 8	12-20-51	....	8	3.2	16	10		49	134	31	32	....	....	260	80	....	....	6.8
a/ 8	1-30-52	....	10	3.4	16	10		40	110	32	32	....	....	240	76	....	....	6.7
a/ 8	2-28-52	....	11	3.2	19	11	....	....	110	32	40	....	....	230	50	....	....	6.8
a/ 8	5-28-52	....	12	3.9	25	10		63	153	50	45	....	....	....	64	....	....	6.9
a/ 8	9-26-52		[illegible]	2.8	20	3.8				22	40				60			6.9

a/	8	4-29-53	....	14	3.7	....	....	....		....	92	45	34	....	....	....	75	....	....	6.9
a/	8	4-12-54	....	10	1.7	36	7.5		22		127	12	37	....	....	....	62	....	....	6.8
	8	1-17-56	....	12	9.4	14	4.5		55		149	5.8	29	0.6	2.5	201	53	0	348	8.3
	8	7-23-57	58	9.6	6.0	19	4.5	50		5.4	162	4.0	26	.9	3.2	226	66	0	367	6.8
	10	4-13-51	57	....	6.3	....	....		43		204	5.4	14	....	.3	202	100	0	368	6.3
	10	12-23-53	57	....	6.3	....	....		23		224	2.9	18	....	1.8	260	164	....	473	6.9
	10	2-19-54	57	7.3	29	38	14	30		7.0	230	1.1	16	.6	.6	246	152	....	469	7.2
	10	10- 8-54	57	....	5.9	....	....		27		226	5.6	17	....	.2	277	156	0	503	6.7
	13	2-24-51	57	18	292	28	12	19		6.6	98	9.0	23	0	4.1	194	120	39	464	6.7
	14	2-27-51	62	19	429	34	13	13		7.7	143	4.9	28	.1	1.0	283	138	21	490	6.8

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
15	2-28-51	58	7.5	170	22	10	21	7.0	129	5.9	11	.1	1.0	172	96	0	366	6.7
16	2-26-51	60	11	182	24	13	12	7.2	120	4.0	18	.2	1.0	174	113	15	385	6.7
25	7-23-57	58	11	3.3	16	3.3	38	5.6	136	13	14	.6	.3	176	54	0	320	7.0
26	1-17-56	....	12	11	48	28	36		153	124	35	.5	9.8	390	235	110	615	7.8
26	7-23-57	61	15	2.4	46	24	37	4.8	165	124	33	.3	3.7	396	215	80	671	6.5
28	7-23-57	57	11	11	36	20	23	3.5	156	58	26	.3	8.1	290	172	44	513	6.5
43	8-11-53	56	20	2.6	....	....	15		196	55	25	....	1.1	....	222	61	538	6.1
43	10- 1-54	57	....	3.3	....	....	14		198	57	28	....	0.5	....	230	68	571	6.3
44	5-18-53	56	....	9.9	....	....	....	....	212	....	28	....	....	....	252	78	560	7.9

44	12-22-53	54	....	6.1	....	....		25		212	78	28	....	.2	....	240	66	624	6.1
44	2-18-54	55	22	4.2	40	21	22		1.9	199	55	29	0.1	.8	310	194	31	549	6.6
44	2-24-56	....	20	25	45	34		38		310	35	31	.4	.3	345	252	0	625	7.0
45	5- 7-54	55	7.6	.18	....	....		18		240	457	40	....	56	....	734	537	1,380	6.5
45	1-18-56	....	7.3	.15	72	135		20		252	428	32	.1	100	1,150	735	528	1,310	6.8
45	6-20-56	58	....	....	....	....	....		....	....	....	....	....	173	....	....	....	1,270	6.6
48	1-14-46	59	....	....	....	....		66		150	113	70	....	36	....	225	....	781	6.0
48	4-16-46	60	15	.04	46	38	44		2.4	148	116	70	.2	35	471	271	....	768	6.1
48	4-10-47	59	....	.17	52	42		48		152	128	70	....	62	....	302	....	804	6.1
48	4-20-53	61	....	1.5	....	....	....		....	148	....	70	....	....	....	276	155	751	7.5

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
48	9- 3-53	60	26	....	....	....	38		124	126	70	....	62	....	298	196	778	6.1
48	12-22-53	61	....	.8	....	....	31		118	121	68	....	25	....	272	175	765	6.2
48	2-19-54	60	20	1.5	44	43	44	6.0	120	110	68	.2	51	467	274	176	740	7.0
48	10- 8-54	63	....	.90	....	....	40		110	127	65	....	40	....	260	170	738	6.3
48	1-20-56	....	22	.33	43	40	41		127	125	66	.3	42	468	272	168	732	8.0
49	12- 2-49	60	14	1.0	48	34	45	12	98	118	88	0.0	49	494	260	179	816	6.1
49	1- 6-50	60	....	....	....	....	....	....	98	121	86	....	42	....	241	161	811	6.3
49	3- 8-50	60	....	....	....	....	61	3	101	124	84	....	49	....	....	....	784	6.1
49	4- 6-50	60	....	....	....	....	57	3	102	121	84	....	50	....	244	....	787	6.1

49	5- 8-50	60	....	....	....	....	....		....	102	122	86	....	60	....	242	....	779	6.2
49	6- 8-50	61	....	....	....	....	....		....	103	117	84	....	33	....	236	....	763	6.1
50	1-14-46	59	....	....	....	....	....		....	150	113	70	....	36	....	225	....	781	6.0
50	4-16-46	60	15	0.04	46	38	44		2.4	148	116	70	0.2	35	471	271	....	768	6.1
50	4-10-47	59	....	.17	52	42		48		152	128	70	....	62	....	302	....	804	6.1
50	2-16-53	----	....	....	46.7	19	....		....	146	115	70	....	....	423	197	....	....	6.1
60	1-14-46	57	....	34	....	....	....		....	166	496	64	....	1.6	....	570	....	1,320	6.0
60	4-22-53	----	....	....	....	....	....		....	92	....	118	....	....	....	614	539	1,430	6.9
60	8-11-53	61	28	1.7	....	....		93		0	244	289	....	.3	....	460	460	1,710	3.0
60	12-22-53	58	....	6.1	....	....		70		64	442	120	....	.8	....	530	478	1,310	5.7

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
60	2-19-54	58	29	25	96	48	77	3.4	84	360	94	.1	.7	854	437	368	1,180	6.4
60	10- 1-54	57	....	3.3	....	....	74		68	412	132	....	1.3	....	510	454	1,300	5.8
62	8-11-53	56	20	.02	....	....	29		40	209	43	....	19	450	264	231	719	6.1
66	1-15-46	56	....	....	....	....	....	....	260	51	16	....	.2	....	52	....	555	6.9
73	11-19-45	58	....	64	....	....	....	....	0	995	235	....	.8	1,400	945	....	2,390	3.65
73	8-11-53	62	15	2.8	....	....	204		450	498	302	....	0.5	1,360	870	501	2,370	6.2
76	11-19-45	59	....	82	....	....	....	....	506	84	52	....	.1	600	442	....	1,010	6.4
83	4-11-47	66	....	.17	136	114	97		184	667	122	....	2.0	....	808	....	1,730	6.5
83	12-28-53	69	....	6.0	....	....	65		230	440	70	....	.1	....	605	417	1,300	6.4

83	2-24-54	68	39	44	118	95	81		2.8	188	510	108	0.2	.8	1,210	685	531	1,580	6.8
83	9-29-54	69	....	6.1	....	....		84		204	502	102	....	.1	....	650	483	1,510	6.2
83	1-19-56	....	37	8.4	117	100		127		171	650	114	.4	2.0	1,270	703	563	1,670	7.0
84	9-29-54	67	....	6.3	....	....		173		260	580	226	....	.1	....	760	547	2,110	6.2
85	11-14-45	56	....	....	....	....	....		....	320	259	78	....	34	....	472	....	1,230	6.2
85	12-30-53	57	....	6.1	....	....		52		266	249	40	....	.1	....	420	202	1,100	6.3
85	2-19-54	57	25	5.5	69	62	50		2.7	230	218	52	.1	.7	668	427	239	976	7.7
85	9-30-54	57	....	3.0	....	....		33		284	242	44	....	.1	....	475	242	1,080	6.5
87	11-14-45	56	....	5.4	....	....	....		....	515	306	30	....	25	....	690	....	1,320	7.3
88	4-10-46	54	....	....	....	....	....		....	181	357	79	....	50	....	562	....	1,260	6.2

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
88	4-11-47	58	....	.12	102	71	59		156	349	80	....	88	....	546	....	1,230	6.2
90	4-11-47	....	....	.17	136	114	97	3	184	667	122	....	2.0	....	808	....	1,730	6.5
92	1-14-46	60	....	.52	98	90	170		150	579	185	....	53	....	660	....	1,910	6.1
93	4-11-47	59	....	4.6	156	113	252		144	946	205	....	13	....	854	....	2,450	6.1
93	5-19-53	62	....	0.25	....	....	....	....	100	....	61	....	....	....	614	532	1,320	7.9
93	8-11-53	59	20	.40	....	....	49		84	523	58	....	18	....	602	533	1,330	5.9
93	12-22-53	60	....	.8	....	....	63		71	598	62	....	23	....	650	592	1,410	5.9
93	2-18-54	59	27	.72	123	97	28	2.5	86	540	62	0.2	42	1,140	661	590	1,410	6.6
93	10- 7-54	60	....	.85	....	....	49		68	789	31	....	31	....	840	784	1,700	6.3

93	1-19-56	....	36	4.3	270	195		24		61	1,340	44	.1	25	2,220	1,480	1,430	2,280	6.8
98	5-27-54	62	17	3.6	....	....		653		100	328	1,220	....	64	....	775	693	4,830	6.3
98	2-24-56	....	14	3.0	92	106		1,360		158	247	2,180	.1	39	4,270	665	536	7,460	7.4
108	7-19-46	....	15	7.4	75	56	68		3.2	316	189	67	.0	15	670	417	....	1,040	6.9
108	5-13-53	62	....	1.1	....	....	....		....	302	....	68	....	....	....	432	185	1,050	7.9
108	8-31-56	66	14	....	84	60		69		306	246	67	.2	5.4	717	456	206	1,070	8.1
120	11- 5-53	59	....	5.9	....	....		43		198	128	62	....	.4	....	290	128	802	6.9
120	12-28-53	59	....	5.9	....	....		36		209	109	66	....	.7	....	300	129	822	7.0
120	2-18-54	58	22	12	69	16	62		3.4	214	92	66	.1	.5	497	238	63	733	7.5
120	10- 1-54	62	....	6.1	....	....		37		202	104	64	....	1.0	....	285	120	813	7.5

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$ Calcium, magnesium	Hardness as $CaCO_3$ Non-carbonate	Specific conductance (micromhos at 25°C)	pH
120	1-19-56	....	28	1.4	56	15		59	165	101	62	.2	1.0	402	201	66	680	8.0
122	9-25-53	64	21	6.2	....	....		8.3	58	18	25	....	.7	....	84	36	241	6.0
122	12-23-53	62	....	6.3	....	....		6.9	67	21	24	....	.5	....	96	41	269	6.3
122	2-18-54	62	21	21	21	6.6	15	4.5	67	18	24	0.2	0.6	151	80	25	229	6.7
122	9-27-54	65	....	5.8	....	....		4.9	30	15	30	....	.2	....	72	47	240	6.8
124	6-16-53	....	20	2.6	....	....		6.7	552	354	33	....	4.0	....	856	404	1,540	6.6
126	5-16-53	60	....	.73	....	....	....	....	148	....	78	....	....	....	308	187	875	7.9
127	5-13-53	61	....	.01	....	....	....	....	40	....	70	....	....	....	240	207	778	7.4
127	9- 4-53	62	20	....	....	....		70	44	143	80	....	128	....	248	212	806	5.9

127	12-21-53	60	....	.06	....	....		24		61	126	76	....	.6	....	236	186	812	6.0
127	2-23-56	61	18	.45	43	27		73		53	135	66	.1	124	521	218	175	765	7.2
128	5-18-53	58	....	.54	....	....	....		....	436	....	94	....	....	....	520	163	1,310	7.6
128	2- 9-56	....	16	.12	88	84		64		402	231	83	.6	20	815	565	236	1,280	6.9
129	10- 8-54	59	20	.40	29	14		79		138	90	50	.1	29	396	130	17	651	8.2
129	2-24-56	60	12	.09	38	24		75		106	117	59	.1	80	455	194	107	715	8.0
132	4-22-46	60	16	2.3	42	32	40		7.1	40	133	50	.2	113	477	236	....	737	5.7
133	4-10-46	58	....	....	....	....	....		....	36	154	78	....	75	....	285	....	861	5.9
133	4-10-47	59	....	.08	48	34		74		80	170	68	....	102	....	260	....	856	6.0
134	7-22-46	60	17	.24	55	43	52		4.3	163	133	73	.1	76	554	314	....	861	6.7

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$ Calcium, magnesium	Hardness as $CaCO_3$ Non-carbonate	Specific conductance (micromhos at 25°C)	pH
139	11-14-45	55	....	....	....	....	....	....	59	52	46	....	15	....	99	....	380	5.8
139	4-22-46	55	13	.02	21	10	26	4.7	56	43	44	.2	8.2	201	94	....	355	5.8
139	5- 6-49	56	16	0.50	22	10	25	3.0	54	44	41	0.1	3.2	207	96	52	333	6.0
140	11-14-45	55	....	....	....	....	....	....	51	63	56	....	27	....	135	....	459	5.5
140	4-10-47	55	....	.17	46	23	34		64	116	70	....	14	....	209	....	634	5.6
140	4-29-49	55	18	.33	72	36	57	16	104	211	90	0.1	22	600	328	242	898	5.9
143	11-15-45	55	....	18	....	....	....	....	144	61	72	....	.2	....	172	....	582	6.1
143	4-16-46	56	9.0	22	36	21	46	6.8	152	59	72	.2	.2	326	176	....	603	6.1
143	4-10-47	55	....	10	45	23	59		182	86	68	....	.2	....	207	....	673	6.1

143	1- 6-50	56	9.2	42	46	23	32		3.2	124	77	77	.2	2.0	375	209	108	713	6.2
144	2- 7-50	56	....	....	....	....		61		187	62	71	....	.1	....	186	33	649	6.0
144	3- 8-50	56	....	....	....	....		112		312	60	72	....	.2	....	176	0	814	6.4
144	4- 6-50	55	....	....	....	....		59		174	57	70	....	.2	....	172	29	627	6.0
144	5- 8-50	55	....	....	....	....		64		206	57	70	....	1.2	....	188	19	670	6.2
144	6- 8-50	56	....	....	....	....		68		202	53	71	....	1.0	....	173	7.5	656	6.3
144	7-10-50	55	....	....	....	....		61		204	59	67	....	.1	....	190	23	667	5.9
144	9- 7-50	....	....	....	....	....		67		196	82	64	....	.2	....	190	29	786	6.2
144	10-11-50	55	....	....	....	....		81		152	110	83	....	.3	....	180	55	668	6.1
144	11- 3-50	55	....	....	....	....		66		182	71	84	....	.3	....	199	50	712	6.1

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$ Calcium, magnesium	Hardness as $CaCO_3$ Non-carbonate	Specific conductance (micromhos at 25°C)	pH
144	1- 8-51	55	....	....	....	....	94		144	141	116	....	.3	....	225	107	944	6.1
144	4- 6-51	55	....	79	....	....	144		224	179	118	....	0.2	....	224	40	1,030	6.2
144	2- 7-52	56	....	....	....	....	64		34	181	103	....	21	....	240	212	814	7.6
144	6- 9-52	55	....	31	....	....	116		128	122	92	....	.2	....	110	5	765	6.9
144	12-22-52	56	....	....	....	....	....	....	....	....	111	....	....	....	350	....	1,080	....
144	5-25-53	56	13	5.9	....	....	52		88	141	87	....	2.7	....	230	158	754	5.8
144	9- 4-53	55	10	5.8	....	....	56		82	156	88	....	.4	....	232	165	778	5.7
144	9-29-54	55	....	6.1	....	....	72		74	183	98	....	.6	....	234	173	824	6.2
145	12- 2-49	56	10	21	51	28	46	2.8	151	98	76	0.0	4.5	406	242	119	722	5.9

145	8- 8-50	56	....	....	....	....		50		148	91	73	....	.2	....	210	89	653	6.0
145	12- 8-50	56	....	....	....	....		56		86	157	74	....	.3	....	216	146	709	5.7
145	2- 2-51	56	....	....	....	....		42		96	110	80	....	6.8	....	220	141	652	5.8
145	5-31-51	56	....	27	....	....		60		135	109	82	....	.7	....	210	99	684	6.2
145	12- 3-51	56	....	1.4	....	....		36		104	112	93	....	7.5	....	260	175	714	5.8
145	4- 8-52	56	....	.91	....	....		97		104	121	95	....	8.4	....	140	55	751	6.8
145	9-16-52	57	....	....	....	....	....		....	....	....	99	....	....	....	286	....	871	----
145	1-29-53	57	....	....	....	....	....		....	....	....	100	....	....	....	350	....	1,010	----
145	12-28-53	57	....	7.4	....	....		68		218	208	105	....	5.0	....	400	221	1,130	7.4
145	2- 8-54	55	15	10	59	52	60		2.5	220	172	101	.3	4.7	697	361	181	997	6.8

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH
146	11-20-45	58	....	....	....	....	....	....	452	298	127	....	28	....	652	....	1,590	6.8
146	4-16-46	58	14	1.2	96	103	100	12	430	304	135	0.2	33	1,070	663	....	1,620	6.8
146	2- 9-56	....	20	.36	63	75	64		330	200	76	.1	24	709	466	195	1,100	7.8
147	11-20-45	58	....	....	....	....	....	....	502	371	132	....	22	....	728	....	1,750	6.3
148	11-20-45	58	....	1.5	....	....	....	....	284	216	124	....	16	....	435	....	1,210	6.1
152	12- 2-49	56	7.5	1.0	13	3.2	20	4.1	80	16	9.5	.1	.7	116	46	0	205	6.7
152	12-28-53	55	....	3.3	....	....	16		210	3.6	10	....	.2	....	156	....	424	7.2
152	2- 8-54	54	8.6	6.1	42	13	17	10	210	7.6	10	.3	.7	246	179	....	388	7.1
152	9-29-54	56	....	5.6	....	....	15		200	6.2	10	....	5.2	....	156	0	418	7.3

152	1-20-56	....	11	5.3	49	12		25		246	5.8	8.0	.3	7.7	261	172	0	416	7.9
159	1-10-46	62	....	....	....	....	....		....	84	139	62	....	71	....	278	....	769	6.1
160	1-10-46	60	....	....	....	....	....		....	70	150	62	....	69	....	252	....	774	5.9
160	4-10-47	61	....	....	45	32		53		56	158	65	....	71	....	244	....	769	6.0
160	10-13-53	62	....	.14	....	....		35		68	164	60	....	26	....	250	199	724	6.1
163	4-10-47	59	....	.08	45	25		56		68	125	82	....	45	....	215	....	713	5.8
163	10-13-53	60	....	.15	....	....		45		57	166	70	....	23	....	240	193	735	6.2
163	12-22-53	60	....	1.4	....	....		33		65	146	76	....	24	....	260	207	779	6.3
163	2- 8-54	58	18	.25	41	32	43		5.5	54	130	68	.1	70	449	234	190	665	6.9
163	9-27-54	61	....	0.57	....	....		49		50	155	70	....	45	....	230	189	741	6.6

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH
163	2-23-56	62	20	.59	41	26	58	54	146	68	0.1	53	476	209	165	721	7.5
164	10-13-53	60	....	.14	....	....	31	70	172	78	....	25	....	300	243	875	6.0
164	2-23-56	61	19	.56	46	30	60	67	154	64	.1	78	491	238	183	756	7.4
172	10- 8-54	59	11	.40	24	16	16	104	16	29	.3	21	212	126	40	366	8.2
172	2- 9-56	....	13	1.3	19	13	29	156	9.0	18	.3	1.2	182	101	0	323	7.4
175	5- 6-54	62	....	.04	....	....	29	60	122	56	....	29	....	216	167	699	6.9
175	9-27-54	61	14	.10	38	20	57	56	135	52	.1	50	420	177	131	631	8.0
175	2-23-56	62	15	.37	47	26	58	89	155	46	.1	62	469	224	151	719	8.1
180	5-13-54	59	....	1.1	....	....	31	131	58	50	....	22	....	188	81	624	6.5

180	10- 8-54	59	16	.03	36	20		48		104	64	56	.1	55	410	172	87	628	8.2
180	2- 9-56	....	17	.32	39	23		43		124	63	66	.2	30	417	192	90	656	7.4
181	1-11-46	60	....	....	....	....	....		....	114	119	78	....	20	....	234	....	720	6.2
181	4- 8-52	60	....	.12	....	....		50		104	120	97	....	28	....	260	175	814	6.3
181	9-16-52	60	....	....	....	....	....		....	....	....	123	....	....	...	280	....	1,000	....
181	5-25-53	61	16	.29	....	....		44		90	119	94	....	19	....	250	176	804	6.1
184	12- 2-49	60	14	1.0	48	34	45		12	98	118	88	.0	49	494	260	179	816	6.1
184	1- 6-50	60	....	.42	....	....	....		....	98	121	86	....	42	....	241	161	811	6.3
184	3- 8-50	60	....	....	....	....		61		101	124	84	....	49	....	238	155	784	6.1
184	4- 6-50	60	....	....	....	....		57		102	121	84	....	50	....	244	160	787	6.1

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH
184	5- 8-50	60	....	....	....	....		64	102	122	86	....	60	....	242	158	779	6.2
184	6- 8-50	61	....	....	....	....		53	103	117	84	....	33	....	236	152	763	6.1
184	10-11-50	61	....	....	....	....		23	58	100	55	....	27	....	200	152	635	6.2
184	12- 3-51	60	....	0.92	....	....		53	108	126	108	....	30	....	280	192	882	6.4
184	2- 7-52	60	....	....	....	....		49	108	125	106	....	24	....	280	192	835	6.4
184	4- 8-52	61	....	.19	....	....		59	114	121	100	....	21	....	250	157	829	6.3
184	6- 9-52	61	....	....	....	....		105	98	128	102	....	32	....	155	75	870	6.2
184	9-16-52	61	....	....	....	....	....	....	....	....	87	....	....	....	238	....	797	....
184	12-22-52	60	....	....	....	....	....	....	....	....	90	....	....	....	250	....	807	....

184	1-29-53	61	....	....	....	....	....	....	90	....	89	....	....	....	242	....	803	6.4
184	2- 8-56	....	17	.13	46	36		58	112	127	83	0.1	58	499	263	171	781	7.6
185	1-11-46	60	....	....	....	....	....	....	100	117	78	....	33	....	210	....	717	6.4
185	4-11-47	60	....	....	45	30		61	88	135	75	....	62	....	236	....	789	6.2
185	7-10-50	60	....	....	....	....		34	132	99	74	....	23	....	260	152	716	6.0
185	8- 8-50	60	....	....	....	....		48	122	106	79	....	28	....	240	140	719	6.3
185	9- 7-50	60	....	....	....	....		47	118	104	81	....	29	....	240	143	740	6.3
185	10-11-50	60	....	....	....	....		48	121	102	80	....	21	....	230	131	738	6.3
185	11- 3-50	60	....	....	....	....		45	117	105	81	....	19	....	236	140	743	6.4
185	12- 8-50	60	....	....	....	....		44	119	103	84	....	17	....	242	145	762	6.3

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$ Calcium, magnesium	Hardness as $CaCO_3$ Non-carbonate	Specific conductance (micromhos at 25°C)	pH
185	1- 8-51	58	....	....	....	....		45	116	106	86	....	14	....	241	146	765	6.3
185	2- 2-51	60	....	....	....	....		44	112	110	88	....	31	....	260	168	757	6.7
185	4- 6-51	60	....	0.77	....	....		58	116	112	91	....	32	....	240	145	760	6.3
185	5-31-51	60	....	.38	....	....		52	120	110	91	....	28	....	250	152	765	6.7
185	9- 4-53	60	8.4	....	....	....		35	102	97	88	....	39	....	264	180	704	6.1
185	12-21-53	60	....	.10	....	....		39	100	97	85	....	21	....	235	153	744	6.5
185	2- 8-54	59	14	.32	39	34	35	11	100	83	78	0.1	43	406	237	155	627	7.3
185	9-24-54	60	....	.11	....	....		42	104	96	78	....	31	....	228	143	716	6.5
202	5-12-54	59	....	1.6	....	....		37	141	73	86	....	9.2	....	240	124	739	6.7

203	2- 8-56	....	21	5.2	54	47		76		360	17	120	.2	13	541	328	33	944	8.0
205	12-12-45	....	....	.10	....	....	....		....	62	90	80	....	17	....	168	....	583	6.5
205	12- 6-49	59	9.2	1.0	85	45	22		16	55	108	198	.0	19	686	397	352	1,020	6.3
205	1- 6-50	59	....	.42	....	....		37		56	112	184	....	20	....	358	312	978	6.5
205	2- 7-50	59	....	....	....	....		33		60	115	126	....	23	....	294	245	806	6.3
205	3- 8-50	58	....	....	....	....		38		58	121	159	....	26	....	336	288	905	6.3
205	4- 6-50	58	....	....	....	....		38		60	125	141	....	25	....	316	267	863	6.3
205	5- 8-50	60	....	....	....	....		35		62	131	118	....	16	....	290	239	796	6.8
205	6- 8-50	60	....	....	....	....		36		62	129	126	....	16	....	298	247	821	6.3
205	7-10-50	59	....	....	....	....		29		66	134	128	....	12	....	320	266	842	6.2

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$ Calcium, magnesium	Hardness as $CaCO_3$ Non-carbonate	Specific conductance (micromhos at 25°C)	pH
205	8- 8-50	59	....	....	....	....	39	67	142	119	....	18	....	300	245	823	6.4
205	9- 7-50	59	....	....	....	....	37	67	130	128	....	11	....	300	245	840	6.5
205	1- 8-51	57	....	....	....	....	36	76	116	68	....	12	....	210	148	618	6.6
205	2- 3-51	58	....	....	....	....	30	76	107	74	....	8.3	....	220	158	622	6.9
205	4- 6-51	59	....	0.33	....	....	39	84	105	70	....	15	....	204	135	597	6.8
205	5-31-51	59	....	.33	....	....	36	85	104	78	....	14	....	220	150	627	7.0
205	12- 3-51	59	....	.68	....	....	39	78	111	126	....	10	....	280	216	793	6.6
205	2- 8-52	59	....	....	....	....	38	84	119	108	....	10	....	270	201	778	7.0
205	4- 8-52	59	....	.20	....	....	35	86	114	74	....	17	....	230	160	674	6.6

205	6- 9-52	60	....	.38	....	....		27		82	114	68	....	8.1	....	230	163	643	6.6
205	9-16-52	60	....	....	....	....	....		....	82	....	62	....	....	....	198	....	626	6.9
205	12-22-52	60	....	....	....	....	....		....	....	....	54	....	....	....	184	....	590	....
205	1-29-53	60	....	....	....	....	....		....	....	....	51	....	....	....	178	....	573	....
205	5-25-53	60	12	1.2	....	....		31		88	105	54	....	18	....	204	132	609	6.6
205	9- 4-53	60	10	....	....	....		31		80	97	75	....	25	....	224	158	647	6.6
205	12-21-53	60	....	0.06	....	....		34		88	100	66	....	19	....	210	138	658	6.6
205	2- 8-54	59	8.2	.13	45	26	31		16	88	86	73	0.1	42	417	219	147	601	7.6
205	9-24-54	61	....	.04	....	....		46		138	76	68	....	32	....	214	101	677	7.1
205	1-20-56	....	12	.43	34	19		44		100	80	60	.2	8.9	331	163	81	543	8.0

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH
206	5-13-54	59	....	1.2	....	....		21	90	66	62	....	4.2	....	188	114	615	6.5
206	2-10-56	....	11	.29	31	20		39	122	65	45	.2	16	311	160	60	500	7.5
225	11- 4-53	58	....	6.1	....	....		43	113	125	65	....	.0	....	220	127	675	6.3
225	9-24-54	....	20	6.3	64	13		45	96	150	54	.1	.6	424	213	134	637	8.1
225	2-10-56	....	22	4.8	65	13		51	142	137	47	.2	0	432	216	99	626	7.8
228	5-18-54	59	....	6.1	....	....		25	70	98	46	....	.2	....	170	113	496	6.1
235	11-14-45	62	....	....	....	....	....	....	327	82	82	....	42	....	368	....	1,000	6.3
235	4-10-47	61	....	.08	60	46		70	316	81	75	....	51	....	339	....	954	6.3
237	4-16-46	59	11	.03	62	37	63	6.8	180	120	92	.2	70	564	307	....	949	6.3

242	1-10-46	58	....	14	....	....	....		....	120	14	24	....	.2	....	90	....	292	6.2
242	4-10-47	57	....	12	24	15		24		160	13	20	....	.5	....	122	....	347	6.6
247	5-19-54	61	....	.6	....	....		28		105	103	38	....	15	....	198	112	633	6.3
249	11-15-45	57	....	....	....	....	....		....	149	49	35	....	19	....	120	....	494	6.4
250	11-15-45	57	....	....	....	....	....		....	152	79	49	....	28	....	158	....	630	6.3
250	4-10-47	58	....	0.21	28	21		53		158	64	45	....	15	....	156	....	594	6.4
250	9- 3-53	58	14	2.1	....	....		49		83	119	62	....	46	....	210	142	674	6.1
250	12-21-53	58	....	.2	....	....		35		88	108	65	....	5.8	....	204	132	655	6.2
250	2- 8-54	57	9.7	.08	35	29	37		12	64	110	70	0.3	17	382	207	154	594	6.8
250	10- 7-54	58	....	1.9	....	....		37		74	110	58	....	23	....	196	135	670	6.0

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
250	1-20-56	....	14	.68	67	54	44		84	284	66	.1	33	645	389	320	941	7.4
252	5-13-54	59	....	.3	....	....	49		122	116	90	....	10	....	250	150	827	6.5
252	1-20-56	....	12	.16	48	29	40		112	100	80	.2	21	455	239	147	729	8.1
270	12- 3-53	61	....	1.0	....	....	25		67	145	66	....	6.9	....	250	195	734	6.0
270	2-15-54	61	11	1.1	44	32	40	18	76	139	64	.2	49	456	241	179	721	6.5
270	9-23-54	61	....	1.4	....	....	40		72	141	61	....	31	....	230	171	734	6.0
270	2-10-56	....	16	.29	37	30	58		82	157	62	.1	30	482	216	148	727	7.7
274	12-19-45	58	....	14	....	....	....	....	316	67	64	....	.0	....	262	....	792	6.3
277	9- 4-46	56	24	.02	51	26	36	9.2	42	131	77	.0	44	424	234	....	682	6.4

277	12- 3-53	53	....	.3	....	....		5.4		17	33	13	....	1.3	....	56	42	158	6.5
281	5-12-54	59	....	.1	....	....		29		112	165	44	....	9.8	....	270	178	759	6.5
281	2-29-56	....	9.0	.22	42	31		42		140	133	39	.3	19	409	232	118	664	7.1
288	1- 8-54	75	....	1.5	....	....		21		140	98	28	....	11	....	220	105	599	8.4
288	2-15-54	72	5.6	.57	48	24	31		17	176	85	26	0.1	52	401	218	74	629	7.2
288	9-24-54	69	....	.9	....	....		26		172	88	30	....	34	....	246	105	666	6.7
288	2-10-56	....	8.0	2.1	72	22		47		230	104	32	.2	21	451	270	62	699	8.4
298	5-12-54	59	....	2.5	....	....		45		102	60	36	....	.2	....	104	20	451	8.3
300	5-14-54	59	....	7.2	....	....		34		125	146	70	....	1.3	....	280	178	742	6.3
300	9-27-54	59	20	5.8	54	31		44		124	152	67	.2	3.9	497	262	161	730	8.2

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$ Calcium, magnesium	Hardness as $CaCO_3$ Non-carbonate	Specific conductance (micromhos at 25°C)	pH
304	7-16-53	65	36	....	....	....	175		176	238	305	....	1.2	....	442	298	1,590	6.1
304	8-19-53	65	20	1.0	....	....	161		148	243	277	....	.1	....	416	295	1,580	5.9
304	9-28-53	64	40	6.3	....	....	209		148	247	340	....	.6	....	404	283	1,750	6.0
304	10-19-53	64	....	6.3	....	....	166		143	237	324	....	1.0	....	460	343	1,730	6.1
304	12-29-53	62	....	6.2	....	....	137		176	214	249	....	.5	....	420	276	1,520	6.4
304	2- 3-54	63	22	5.6	106	33	168	1.4	136	205	280	.1	.8	958	400	289	1, 600	7.2
304	9-22-54	64	....	5.9	....	....	147		156	195	282	....	.2	....	410	282	1,550	6.2
305	12-17-45	57	....	24	....	....	....	....	216	176	400	....	.6	....	780	....	1,800	6.6
306	12-17-45	56	....	....	....	....	....	....	44	....	11	....	3.6	....	60	....	179	6.7

306	12- 2-49	....	8.8	4.2	....	....		428		455	292	526	.1	14	1,760	500	127	2,810	6.9
308	12-12-45	64	....	....	....	....	....		....	240	227	71	....	60	....	428	....	1,060	6.2
308	2- 4-54	64	....	2.6	....	....		35		156	202	52	....	12	....	345	217	935	6.5
308	2-10-56	....	9.0	.25	52	32		15		138	105	31	0.2	33	439	261	148	684	7.4
311	3- 3-54	62	....	1.5	....	....		159		157	227	212	....	2.3	....	320	191	1,410	6.5
317	2-18-54	56	19	2.7	60	18	30		1.6	146	69	42	.1	13	336	236	116	578	7.3
317	9-22-54	57	....	5.4	....	....		13		172	48	44	....	.3	....	226	85	561	7.1
323	7-17-53	57	22	....	....	....		6.4		35	5.8	30	....	1.0	....	64	35	198	8.0
329	7-31-53	62	25	.10	50	24	170		9.3	89	137	275	.1	.2	761	223	147	1,340	8.0
329	8-31-53	59	20	2.1	....	....		145		104	136	213	....	.4	....	212	127	1,150	6.0

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
329	9-28-53	62	26	6.1	....	....	140		102	139	200	....	.5	....	206	122	1,080	6.0
329	10-19-53	62	....	6.4	....	....	130		105	128	180	....	.0	....	190	104	1,050	6.5
329	12-29-53	62	....	5.2	....	....	125		104	128	172	....	.3	....	190	105	1,010	6.3
329	2- 3-54	62	25	21	38	25	100	1.8	98	116	144	.2	1.1	538	198	117	958	7.8
329	9-22-54	62	....	5.9	....	....	115		86	116	172	....	.4	....	185	115	979	6.1
329	2-10-56	....	29	5.1	42	18	82		124	109	100	.2	0	455	179	77	730	7.9
336	7-28-53	60	26	....	....	....	35		62	179	55	....	19	....	254	203	663	6.7
337	7-28-53	64	28	....	....	....	42		138	166	45	....	.5	....	258	145	709	7.4
338	7-28-53	57	32	....	....	....	33		170	173	55	....	2.7	....	328	189	816	7.1

338	10-19-53	57	....	.20	....	....		36		159	157	52	....	1.9	....	290	160	775	7.2
344	8- 5-53	56	27	0.05	62	14	20		6.8	84	111	47	0.1	1.9	357	212	140	536	8.1
344	8-26-53	56	20	.40	....	....		20		116	118	44	....	2.0	....	238	143	599	6.5
344	9-28-53	56	23	1.7	....	....		15		120	110	50	....	1.7	....	252	154	594	6.4
344	10-19-53	56	....	1.8	....	....		20		116	112	47	....	1.0	....	235	140	596	6.7
344	12-29-53	56	....	2.0	....	....		22		118	118	56	....	.5	....	250	153	642	6.8
344	2- 3-54	56	25	2.8	71	19	23		6.5	120	110	51	.1	1.3	396	255	157	639	7.5
344	9-22-54	56	....	2.6	....	....		13		120	94	58	....	1.0	....	250	152	641	6.6
344	2-10-56	....	27	1.7	67	15		29		132	108	50	.2	.7	385	229	121	595	8.2
347	8- 4-53	59	32	.02	23	11	10		6.5	50	68	18	.1	.5	198	103	62	272	7.2

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
347	9- 1-53	61	26	6.1	....	....	11		33	70	17	....	.5	....	100	73	271	5.8
347	9-28-53	62	22	6.0	....	....	11		31	72	16	....	.7	....	100	75	266	5.8
347	10-19-53	60	....	8.2	....	....	11		30	63	20	....	.3	....	94	69	269	6.2
347	2- 3-54	63	28	8.3	20	10	7.5	5.0	29	61	16	.1	.8	182	91	67	271	6.3
347	9-23-54	60	....	6.2	....	....	6.6		31	53	21	....	.3	....	96	71	279	5.9
357	8- 5-53	63	29	5.7	47	16	14	5.6	35	153	26	.1	.1	323	183	154	474	7.8
357	9- 1-53	60	6	6.0	....	....	19		40	157	30	....	.4	....	198	165	499	5.6
357	9-28-53	60	22	5.7	....	....	21		36	162	30	....	.4	....	196	166	490	5.5
357	10-19-53	62	....	7.4	....	....	21		34	162	29	....	.1	....	192	164	506	6.0

357	12-29-53	63	....	7.2	....	....		38		67	161	27	....	3.0	....	180	125	561	6.4
357	2- 3-54	64	25	4.6	51	21	19		5.5	30	168	29	0.1	.8	353	214	189	552	6.4
357	9-23-54	65	....	6.2	....	....		19		26	175	31	....	.2	....	206	185	548	6.0
373	1-25-54	55	19	4.6	26	14	15		1.9	88	24	22	.2	46	212	122	50	349	7.2
373	9-23-54	60	....	5.4	....	....		29		158	22	17	....	.3	....	114	0	413	6.5
373	2-29-56	....	22	4.8	32	13		9.3		130	20	18	.3	0	199	133	27	346	7.0
389	12- 4-53	62	....	4.1	....	....		129		354	166	224	....	1.0	....	500	210	1,710	6.8
389	9-27-54	64	8.9	6.3	127	29		356		136	208	625	.3	.2	1,550	436	325	2,600	6.9
392	1- 8-54	74	....	16	....	....		220		0	1,250	150	....	19	....	1,050	1,050	2,560	4.4
392	9-22-54	69	22	6.3	167	32		364		0	918	270	1.0	.3	1,810	548	548	3,280	2.65

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH
395	1- 8-54	....	....	18	....	....	65		106	194	51	....	.9	....	220	133	724	6.9
398	9-23-54	59	....	5.6	....	....	7.0		48	21	9	....	.5	....	59	20	180	6.5
407	12- 2-49	57	8.2	4.2	23	5.7	11	4.2	86	21	14	.0	1.9	136	81	10	244	6.5
407	1- 6-50	57	....	5.2	....	....	....	....	90	20	14	....	2.1	....	80	6.2	244	6.9
407	2- 7-50	57	....	....	....	....	15		86	24	12	....	1.4	....	80	9.6	235	6.8
407	3- 8-50	58	....	....	....	....	17		89	28	12	....	1.8	....	83	10	240	6.8
407	4- 6-50	57	....	....	....	....	16		90	26	12	....	.2	....	82	8	240	6.9
407	5- 8-50	57	....	....	....	....	15		88	21	12	....	1.7	....	79	7	226	6.8
407	6- 8-50	59	....	....	....	....	15		88	19	13	....	0.9	....	78	5.9	225	6.6

407	7-10-50	57	....	....	....	....	14	89	20	11	....	1.5	....	80	7	228	6.2
407	8- 8-50	57	....	....	....	....	14	98	17	10	....	1.3	....	82	2	227	6.8
407	9- 7-50	57	....	....	....	....	14	93	15	10	....	1.5	....	76	0	220	6.8
407	10-11-50	57	....	....	....	....	15	95	13	10	....	1.9	....	74	0	221	6.9
407	11- 3-50	57	....	....	....	....	19	103	19	10	....	1.4	.	79	0	236	6.7
407	1- 8-51	56	....	....	....	....	19	89	19	10	....	2.0	....	67	0	219	6.6
407	2- 2-51	56	....	....	....	....	14	87	17	11	....	2.4	....	76	5	219	6.8
407	4- 6-51	59	....	12	....	....	16	92	21	10	....	1.8	....	78	3	216	6.8
407	5-31-51	59	....	....	....	....	16	88	21	12	....	1.9	....	77	5	220	7.1
407	8- 6-51	....	....	....	84	....	12	88	19	12	....	1.7	....	84	12	227	6.7

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

<table>
<tr><th rowspan="2">Well no.</th><th rowspan="2">Date of collection</th><th rowspan="2">Temperature (°F)</th><th rowspan="2">Silica (SiO_2)</th><th rowspan="2">Total iron (Fe)</th><th rowspan="2">Calcium (Ca)</th><th rowspan="2">Magnesium (Mg)</th><th rowspan="2">Sodium (Na)</th><th rowspan="2">Potassium (K)</th><th rowspan="2">Bicarbonate (HCO_3)</th><th rowspan="2">Sulfate (SO_4)</th><th rowspan="2">Chloride (Cl)</th><th rowspan="2">Fluoride (F)</th><th rowspan="2">Nitrate (NO_3)</th><th rowspan="2">Dissolved solids (residue on evaporation at 180°C)</th><th colspan="2">Hardness as $CaCO_3$</th><th rowspan="2">Specific conductance (micromhos at 25°C)</th><th rowspan="2">pH</th></tr>
<tr><th>Calcium, magnesium</th><th>Non-carbonate</th></tr>
<tr><td>407</td><td>12- 3-51</td><td>56</td><td>.......</td><td>3.7</td><td>.......</td><td>.......</td><td colspan="2">13</td><td>80</td><td>34</td><td>19</td><td>.......</td><td>1.8</td><td>.......</td><td>100</td><td>34</td><td>276</td><td>6.9</td></tr>
<tr><td>407</td><td>2- 7-52</td><td>57</td><td>.......</td><td>.......</td><td>.......</td><td>.......</td><td colspan="2">12</td><td>80</td><td>32</td><td>19</td><td>.......</td><td>1.4</td><td>.......</td><td>100</td><td>34</td><td>279</td><td>6.8</td></tr>
<tr><td>407</td><td>5-25-53</td><td>57</td><td>10</td><td>3.3</td><td>.......</td><td>.......</td><td colspan="2">10</td><td>80</td><td>24</td><td>10</td><td>.......</td><td>2.3</td><td>.......</td><td>84</td><td>18</td><td>228</td><td>6.4</td></tr>
<tr><td>407</td><td>9- 4-53</td><td>57</td><td>9.2</td><td>.......</td><td>.......</td><td>.......</td><td colspan="2">8.4</td><td>72</td><td>23</td><td>11</td><td>.......</td><td>2.2</td><td>.......</td><td>82</td><td>23</td><td>223</td><td>6.3</td></tr>
<tr><td>407</td><td>12-28-53</td><td>57</td><td>.......</td><td>4.9</td><td>.......</td><td>.......</td><td colspan="2">9.3</td><td>72</td><td>16</td><td>16</td><td>.......</td><td>2.5</td><td>.......</td><td>80</td><td>21</td><td>227</td><td>6.8</td></tr>
<tr><td>407</td><td>2- 8-54</td><td>56</td><td>8.6</td><td>4.4</td><td>21</td><td>6.4</td><td>9.2</td><td>5.5</td><td>71</td><td>19</td><td>13</td><td>0.2</td><td>3.2</td><td>124</td><td>79</td><td>21</td><td>234</td><td>7.6</td></tr>
<tr><td>407</td><td>9-29-54</td><td>57</td><td>.......</td><td>5.6</td><td>.......</td><td>.......</td><td colspan="2">9.2</td><td>74</td><td>20</td><td>11</td><td>.......</td><td>1.4</td><td>.......</td><td>78</td><td>17</td><td>225</td><td>6.5</td></tr>
<tr><td>407</td><td>2- 9-56</td><td>....</td><td>10</td><td>3.3</td><td>21</td><td>5.0</td><td colspan="2">15</td><td>85</td><td>18</td><td>11</td><td>0.1</td><td>2.1</td><td>125</td><td>73</td><td>3</td><td>218</td><td>7.5</td></tr>
<tr><td>411</td><td>5-25-53</td><td>59</td><td>10</td><td>5.7</td><td>.......</td><td>.......</td><td colspan="2">11</td><td>76</td><td>28</td><td>12</td><td>.......</td><td>.5</td><td>.......</td><td>84</td><td>22</td><td>234</td><td>6.4</td></tr>
</table>

411	2- 9-56	62	14	9.0	18	6.5		21		52	4.5	15	.2	59	182	72	29	248	7.3
412	12- 6-49	58	7.5	3.1	23	5.7	12		4.3	90	19	12	.0	2.0	135	81	7	244	6.3
412	1- 6-50	58	....	5.4	....	....		15		90	20	12	....	2.2	....	80	6	242	6.7
412	2- 7-50	60	....	....	....	....		28		143	.8	23	....	.3	....	90	0	315	6.5
412	3- 8-50	63	....	....	....	....		44		178	.8	30	....	2.0	....	94	0	398	6.6
412	4- 6-50	63	....	....	....	....		54		130	10	30	....	.4	....	86	0	341	6.5
412	5- 8-50	64	....	....	....	....		33		119	14	26	....	1.0	....	78	0	322	6.6
412	6- 8-50	64	....	....	....	....		18		101	.4	18	....	2.6	....	72	0	227	7.0
412	7- 3-50	63	....	....	....	....		37		140	9.9	20	....	.6	....	74	0	321	6.2
412	8- 8-50	62	....	....	....	....		32		122	12	14	....	1.2	....	64	0	291	6.6

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
														Calcium, magnesium	Non-carbonate		
412	9- 7-50	59	....	....	....	....	25	113	4.9	14	....	1.0	....	64	0	247	6.6
412	10-11-50	63	....	....	....	....	9.9	61	2	14	....	20	....	66	16	293	6.2
412	11- 3-50	59	....	....	....	....	34	125	8.6	16	....	20	....	76	0	303	6.6
412	12- 8-50	66	....	....	....	....	25	88	15	20	....	16	....	74	1.9	287	6.4
412	1- 8-51	65	....	....	....	....	32	96	21	18	....	18	....	70	0	313	6.5
412	2- 2-51	58	....	....	....	....	22	104	19	12	....	1.0	....	74	0	246	6.7
412	3- 7-51	63	....	32	....	....	28	178	0.8	13	....	1.9	....	106	0	337	6.8
412	3- 6-51	62	....	55	....	....	56	280	3.7	12	....	3.0	....	130	0	474	6.7
412	4-12-51	60	....	42	....	....	48	238	2.9	13	....	1.2	....	112	0	421	6.7

412	4-30-51	60	....	36	....	....		47	208	5.4	12	....	1.2	....	92	0	372	6.7
412	5-31-51	59	....	28	....	....		26	180	2.5	12	....	.2	....	110	0	332	6.8
412	8- 6-51	....	....	....	....	....		61	208	2.1	14	....	.2	....	110	0	415	6.5
412	9-12-51	....	....	....	....	....		19	108	9.1	14	....	.4	....	76	0	266	6.3
412	10- 9-51	....	....	....	16	....		6.4	156	7.0	16	....	.4	....	144	16	297	6.5
412	1- 9-52	....	....	....	....	....		32	134	8.6	18	....	.6	....	74	0	326	6.6
412	2- 7-52	64	....	....	....	....		32	140	11	21	....	.5	....	86	0	365	6.8
412	3- 6-52	64	....	5.0	....	....		28	140	6.6	14	....	.3	....	80	0	326	6.6
412	6- 9-52	62	....	8.1	....	....		30	142	7.8	12	....	.7	....	76	0	319	6.6
412	9-16-52	58	....	....	....	....	....	....	....	....	....	....	....	....	90	....	307	....

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
412	11- 9-52	63	....	....	....	....		34	132	11	21	....	.7	....	76	0	329	6.6
412	12-22-52	58	....	....	....	....	....	....	....	....	10	....	....	....	66	....	260	....
412	1-29-53	....	....	....	....	....	....	....	....	....	13	....	....	....	82	....	289	....
412	9- 4-53	61	11	....	....	....		25	58	19	16	....	54	....	80	32	243	6.1
412	12-28-53	66	....	4.0	....	....		18	62	19	50	....	12	....	112	61	370	8.1
412	2- 8-54	66	7.8	4.7	19	8.5	22	4.5	74	20	36	0.1	1.3	169	82	22	338	6.8
412	9-29-54	57	....	6.3	....	....		8.8	53	11	23	....	8.3	....	75	32	238	6.3
426	5- 7-54	57	....	6.9	....	....		18	70	24	28	....	2.7	....	86	29	283	6.3
430	6- 2-54	59	....	3.3	....	....		57	170	52	68	....	6.0	....	170	31	676	6.8

430	2- 9-56	....	12	3.4	29	20		61		208	41	48	.5	5.5	337	155	0	567	8.2
434	3-19-30	....	17	.06	52	35	55		4.5	187	78	83	....	53	489	274	....	....	....
436	11-15-45	58	....	....	....	....	....		....	273	116	82	....	19	....	352	....	908	6.1
436	4-16-46	59	16	.04	61	53	51		8.9	298	123	76	.2	6.7	558	370	....	960	6.2
436	4-10-47	58	....	.12	60	49		58		252	133	68	....	44	....	351	....	917	6.1
442	5-26-54	60	30	.36	....	....		13		16	97	30	....	39	....	160	147	447	5.7
442	1-18-56	....	32	3.1	5.7	.0		68		125	30	18	.1	.4	212	14	0	323	8.3
443	5-26-54	56	14	2.9	....	....		21		25	49	32	....	37	....	100	80	340	5.9
443	1-18-56	....	18	.67	15	15		24		32	54	28	.1	37	206	99	23	339	6.8
444	5-26-54	57	16	.50	....	....		19		27	42	34	....	41	....	105	83	354	6.0

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
444	1-18-56	....	18	.32	23	15	41		34	57	60	.1	45	281	119	91	478	6.6
469	1-12-50	56	19	41	13	6.2	9.8	2.4	75	.2	13	.2	.7	118	58	0	202	6.5
469	2- 9-56	....	6.2	1.0	15	4.7	14		30	35	12	.1	10	114	57	32	189	7.1

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
BUCKS COUNTY																		
479	7-29-53	61	11	....	....	....		4.3	20	19	4	....	1.9	....	34	18	109	6.0
479	10-20-53	59	....	....	....	....		5.9	18	22	4	....	1.9	....	32	17	114	6.1
479	1-21-54	54	20	0.14	6.4	5.7	4.2	1.3	18	26	5.0	0.1	2.2	85	39	25	101	6.3
498	7-29-53	59	19	....	....	....		8.3	60	44	16	....	13	....	110	61	291	6.1
498	1-21-54	58	20	.15	14	8.3	7.2	2.8	26	18	16	.1	34	154	69	48	198	6.9
498	2-27-56	57	11	.04	16	9.3		15	56	31	14	.1	16	160	78	32	260	7.8

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
499	8- 5-53	58	17	....	....	....		16	90	40	26	....	14	....	128	54	379	6.2
499	8-19-53	57	17	....	....	....		18	88	45	26	....	13	....	128	56	373	6.3
499	9- 3-53	59	16	....	....	....		18	80	47	22	....	12	....	115	49	344	6.3
499	10-20-53	59	....	....	....	....		1.6	44	58	17	....	9.2	....	92	56	311	6.2
499	11-13-53	57	....	....	....	....		18	28	65	13	....	10	....	78	55	286	6.1
499	1-21-54	55	8.2	.30	16	8.0	21	2.2	38	59	19	.4	11	205	73	42	309	6.5
499	2-27-56	54	10	5.6	17	5.8		25	38	66	12	.1	5.6	177	66	31	269	7.3
506	2-27-56	60	20	5.6	72	32		34	198	165	35	.3	1.0	518	311	149	765	7.0
507	4-28-53	56	20	7.2	41	12	33	4.5	122	89	25	.2	.5	303	152	52	457	5.9

509	2-27-56	64	15	5.8	25	6.0		25		94	42	14	.1	.4	194	87	10	294	7.7
b/531	7-17-42	....	....	.05	....	....	....		....	....	....	4.0	....	.3	60[1]	20	....	....	6.6
531	8-16-50	57	....	....	....	....		3.4		14	29	8	....	3.0	....	48	37	157	5.9
531	2-28-56	58	13	2.2	8.2	5.4		10		16	32	10	0.1	4.5	98	43	30	152	7.2
b/532	7-17-42	....	....	.05	....	....	....		....	....	....	3.0	....	.3	45[1]	18	....	....	5.6
532	8-16-50	58	....	....	....	....		4.3		11	16	6	....	14	....	36	27	125	5.8
b/533	8-25-42	....	....	....	....	....	....		....	....	....	5.0	....	.1	70[1]	30	....	....	6.2
533	8-16-50	56	....	....	....	....		5.7		29	14	10	....	2.0	....	65	18	174	9.3
533	2-28-56	58	12	5.0	8.2	4.2		15		24	23	14	.1	8.9	118	38	18	161	6.6

1/ 103° C.

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH
b/534	3-23-43	....	....	.1	....	....	....	....	....	....	3.0	....	.1	70[1]	10	....	....	6.4
534	8-16-50	56	....	....	....	....		2.9	8	3.3	5	....	6.6	....	16	9	72	5.9
534	4-15-53	54	9.6	.04	4.1	3.4	5.0	1.7	9	15	7.5	0	5.4	63	24	17	87	5.5
534	2-28-56	56	12	.13	4.5	3.3		8.0	8	13	7.5	.1	14	77	25	18	102	6.8
b/535	8-18-43	....	....	.3	....	....	....	....	....	....	3.0	....	.5	45[1]	....	....	....	....
535	8-16-50	58	....	....	....	....		5.5	7	5.8	8	....	8.6	....	18	12	87	5.5
535	9-12-50	56	....	....	....	....	....	....	18	....	....	....	....	....	....	....	93	....
535	2-28-56	57	11	.50	5.7	4.2		9.1	8	18	9.0	.1	16	81	31	25	118	5.5
537	8-16-50	58	....	....	....	....		7.0	12	14	8	....	18	....	35	25	134	5.6

537	2-28-56	56	14	.14	5.7	6.5		11		9	28	9.0	.1	18	104	41	34	143	6.8
538	8-16-50	56	....	....	....	....		1.2		10	4.9	3	....	8.6	....	22	14	82	6.2
548	2-28-56	56	6.4	.52	12	5.5		8.1		37	26	7.0	0.1	3.5	97	53	22	146	7.5
549	9-17-46	56	11	.01	13	13		3.4		19	48	20	.0	34	163	81	....	260	6.0
551	9-17-46	56	13	.01	11	13	13		3.4	19	48	20	.0	34	163	81	....	260	6.0
551	3- 1-56	59	13	.23	24	20		71		25	41	157	.1	15	455	142	122	759	5.9
556	3- 2-56	60	7.5	6.3	22	5.2		13		70	32	8.0	.1	1.7	126	76	19	209	6.5
562	2-23-45	....	....	.0	....	....	....		....	....	....	10	....	.6	95	58	....	....	5.2
b/563	2-23-45	....	....	.0	....	....	....		....	....	....	10	....	.1	95	48	....	....	6.0

1/ 103° C.

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH
2/	8-16-50	58	....	....	....	....		4.4	15	31	10	....	16	....	62	50	187	6.0
2/	4-15-53	51	6.7	.50	13	9.4	5.0	2.2	15	49	10	.0	11	127	71	59	195	5.8
2/	8- 7-53	58	20	....	....	....		5.1	12	49	9	....	13	....	73	63	195	5.8
2/	9- 8-53	56	11	....	....	....		3.3	4	43	9	....	13	....	64	61	191	5.8
2/	9-29-53	58	20	....	....	....		6.0	16	47	9	....	14	....	73	60	194	5.8
2/	11-13-53	56	....	....	....	....		4.3	13	44	8	....	12	....	68	57	184	5.9
2/	1-20-54	56	8.2	.11	11	9.0	3.5	2.1	15	36	9.0	.1	13	102	64	52	171	6.0
585	4-16-53	53	19	.36	20	3.6	8.5	2.8	38	41	8.0	.1	1.9	127	65	34	176	6.1
591	2-28-56	60	20	.41	21	10		11	55	51	8.0	.1	8.6	157	94	48	238	7.7

595	4-15-53	47	5.1	0.04	12	6.2	8.3		1.1	50	22	5.0	0.1	4.0	95	55	14	139	6.3
595	2-28-56	....	5.2	.67	12	5.1		11		35	28	8.5	.1	5.0	96	51	22	153	7.6
610	4-24-53	52	20	.06	4.5	2.2	2.2		1.3	8	1.6	5.5	.1	13	58	20	14	68	5.3
612	4-24-53	53	20	1.3	8.1	4.0	5.4		2.2	40	13	4.0	.2	.8	90	37	4	111	6.0
620	9- 7-53	54	16	38	17	12	4.5		1.0	0	102	11	.1	.2	223	92	92	347	3.70
620	3- 1-56	55	17	5.6	17	11		7.8		0	84	12	.1	.1	163	88	88	254	4.5
621	4-30-53	54	17	.10	7.4	5.0	4.7		2.0	23	11	11	.1	7.4	92	39	20	120	7.2
621	3- 1-56	57	26	2.7	16	4.7		10		59	15	12	.1	.7	114	59	11	170	7.6
b/629	3-30-48	....	....	0	....	....	....		....	40	20	6.0	....	.5	105[1]	58	....	----	6.0

1/ 103° C.

2/ Sample represents a mixture of water from Bk-562 and Bk-563.

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
629	8-28-53	54	10	....	....	....		3.5	62	29	8	....	4.2	....	88	37	204	6.7
629	9-29-53	54	10	....	....	....		3.9	62	30	8	....	3.9	....	88	37	207	6.7
629	10-20-53	54	....	....	....	....		1.0	59	29	9	....	3.6	....	92	44	210	6.6
629	11-13-53	54	....	....	....	....		7.8	59	47	8	....	4.1	....	95	47	213	6.7
629	1-20-54	56	12	.06	22	10	3.3	1.0	59	32	10	.1	3.9	125	96	48	212	6.7
629	3- 1-56	56	12	.30	25	11		6.0	79	35	10	.1	6.3	146	108	43	238	6.9
634	9-17-46	55	12	.04	7.9	3.9	3.1	1.3	24	5.2	5.1	.1	12	68	36	....	92	6.8
634	3- 1-56	56	13	.14	12	5.5		8.3	25	24	9.0	.1	15	101	53	32	156	6.3
636	5-25-50	56	12	0.03	9.4	4.4	4.8	0.9	24	20	5.2	0.1	5.8	77	42	22	118	6.5

636	3- 1-56	56	13	.70	15	4.5		8.7		27	25	8.5	.1	18	110	56	34	163	6.4
638	6-13-50	58	6.9	1.6	22	8.5	5.6		2.5	62	37	9.9	.0	3.4	134	90	39	225	6.5
638	7-28-53	59	11	-------	-------	-------		6.3		52	41	10	-------	5.3	-------	90	47	219	6.2
638	8- 5-53	59	11	-------	-------	-------		7.9		56	42	10	-------	5.6	-------	91	45	222	6.3
638	8-28-53	56	11	-------	-------	-------		5.7		52	40	10	-------	5.1	-------	90	47	218	6.3
638	9- 8-53	55	10	-------	-------	-------		6.5		52	40	11	-------	5.4	-------	90	47	219	6.4
638	9-29-53	55	10	-------	-------	-------		5.7		50	41	10	-------	5.7	-------	90	49	221	6.3
638	10-20-53	58	-------	-------	-------	-------		4.0		51	46	14	-------	3.9	-------	104	62	250	6.5
638	11-13-53	56	-------	-------	-------	-------		2.3		51	42	13	-------	4.0	-------	102	60	242	6.5
638	1-20-54	60	7.0	.72	20	9.7	3.9		2.0	50	34	11	.2	4.8	126	90	49	217	6.7

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health.

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH
638	3- 1-56	57	7.4	.49	23	8.0		6.8	61	35	10	.1	5.5	126	90	53	220	6.7
639	6-13-50	55	7.4	.19	34	19	8.5	3.4	71	74	21	0	20	231	163	105	387	6.7
640	6-13-50	54	6.1	.84	29	17	11	2.1	36	87	20	.2	33	244	142	113	388	6.5
641	6-13-50	53	9.2	.08	32	14	10	2.6	32	92	16	.0	23	225	137	111	353	6.2
642	6-13-50	53	9.9	.43	57	43	76	12	53	189	122	0	107	716	319	276	1,090	6.3
643	6-13-50	53	14	2.0	8.2	7.6	11	1.8	8	45	17	.1	1.2	115	52	45	183	5.2
644	6-13-50	53	7.0	0.27	28	22	61	12	123	115	34	0.0	52	398	160	60	645	6.5
645	5-25-50	56	7.4	.06	47	25	5.9	3.4	60	113	24	.1	42	334	220	171	503	6.4
b/647	10-23-44	....	....	0	....	....	....	....	....	....	15	....	7.0	210[1]	140	....	....	6.9

b/647	3-28-45	....	....	....	....	....	....	....	....	....	17	....	10	190[1]	140	....	....	6.3
651	3- 1-56	57	9.2	1.8	24	12		5.8	45	60	11	.1	8.4	163	109	72	262	6.3
652	3- 1-56	55	8.5	5.4	21	10		10	46	49	9.0	.1	18	157	94	56	249	6.3
670	7-28-53	59	11	....	....	....		2.9	56	28	4	....	6.8	....	80	34	178	6.3
670	8- 5-53	58	11	....	....	....		.8	64	21	4	....	5.9	....	83	31	185	6.2
670	9- 8-53	58	12	....	....	....		.9	64	20	5	....	5.8	....	83	31	190	6.3
670	9-29-53	58	12	....	....	....		1.2	62	22	5	....	4.8	....	82	31	190	6.2
670	10-20-53	60	....	....	....	....		2.3	71	19	6	....	3.1	....	84	26	205	6.4
670	11-13-53	56	....	....	....	....		1.8	79	16	6	....	.2	....	86	21	217	6.6

1/ 103° C.

a/ Chemical analysis by U.S. Navy.

b/ Chemical analysis by Pennsylvania Department of Health

TABLE 12.—CHEMICAL ANALYSES, Continued

Well no.	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
															Calcium, magnesium	Non-carbonate		
670	1-20-54	59	7.8	11	18	9.3	3.3	2.2	62	22	7.5	.1	3.7	107	83	32	191	8.0
672	8-28-53	60	17	....	....	....	24		60	105	14	....	1.4	....	128	79	393	6.2
672	10-20-53	57	....	....	....	....	9.3		60	68	14	....	.7	....	120	71	355	6.5
673	12- 1-53	56	....	....	....	....	2.4		90	60	12	....	2.7	....	150	76	353	7.5
673	2- 7-56	....	11	.56	16	8.0	8.2		35	42	7.0	.1	10	124	73	44	189	7.3
688	2-28-56	59	11	0.64	18	11	27		60	47	26	0.1	16	205	90	41	307	6.4
689	3- 1-56	60	9.6	1.1	43	17	18		88	98	12	.1	30	275	177	105	416	6.8
690	3- 1-56	57	9.6	1.4	16	4.4	4.0		62	6.5	3.0	.1	5.9	66	58	7	125	6.8
691	2-28-56	59	8.7	2.1	17	6.6	11		70	21	8.0	.1	3.3	116	70	12	186	7.7

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania

Well Ph-1

Altitude: 11 feet

Owner: U. S. Navy Department

Driller: Layne-New York

	Thickness (feet)	Depth (feet)
Recent deposits		
Top soil	8	8
Mud, black, sand, fine	22	30
Pleistocene deposits		
Sand and gravel, gray, coarse	28	58
Raritan formation		
Upper clay member		
Clay, blue	5	63
Old Bridge sand member		
Sand and gravel, coarse	19	82
Middle clay member		
Clay, red, tough	46	128
Sayreville sand member		
Sand	10	138
Lower clay member		
Clay, red, tough	28	166
Farrington sand member		
Sand and gravel, coarse	22	188
Sand with clay streaks	6	194
Sand and gravel	42	236
Crystalline rocks		
Rock	2	238

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Well Ph-2

Altitude: 11 feet

Owner: U. S. Navy Department

Driller: Layne-New York

	Thickness (feet)	Depth (feet)
Recent deposits		
Fill	5	5
Mud, black, and sand, fine	31	36
Pleistocene deposits		
Sand and gravel, coarse	29	65
Raritan formation		
Upper clay member and Middle clay member		
Clay, blue, tough	54	119
Clay, red	8	127
Sayreville sand member		
Sand, brown, coarse	20	147
Lower clay member		
Clay, red, tough	31	178
Farrington sand member		
Sand, and streaks of clay	6	184
Sand and gravel	13	197
Clay, red, hard	2	199
Sand and gravel, coarse	39	238
Crystalline rocks		
Clay	2	240
Rock	3	243

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Well Ph-8

Altitude: 12 feet

Owner: U. S. Navy Department

Driller: Layne-New York

	Thickness (feet)	Depth (feet)
Recent deposits		
Fill and river mud	20	20
Clay, sandy	10	30
Pleistocene deposits		
Sand and clay streaks	40	70
Raritan formation		
Upper clay member and		
Middle clay member		
Clay, red, tough	75	145
Sayreville sand member		
Sand, packed	10	155
Lower clay member		
Clay, red, tough	32	187
Farrington sand member		
Sand, coarse, and fine-grained	45	232
Sand, coarse, and gravel and boulders	6	238
Sand, coarse, and gravel	6	244
Crystalline rocks		
Clay	2	246
Mica rock	8	254

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Well Ph-10

Altitude: 12 feet

Owner: U. S. Navy Department

Driller: Layne-New York

	Thickness (feet)	Depth (feet)
Recent deposits		
Fill	6	6
Sand, gray	2	8
Mud	27	35
Pleistocene deposits		
Sand and clay	6	41
Boulders; clay and sand	9	50
Clay, white, and sand	8	58
Sand, fine	2	60
Sand, coarse	1	61
Raritan formation		
Upper clay member		
Clay, white, tough	3	64
Clay, red, tough	12	76
Old Bridge sand member		
Sand, fine	2	78
Clay, sandy	3	81
Middle clay member		
Clay, white	3	84
Clay, red	5	89
Clay, red, and some pink and white clay	21	110
Clay, red	10	120
Clay, blue	10	130
Sayreville sand member		
Sand, medium coarse	10	140
Lower clay member		
Clay	6	146

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Well Ph-19

Altitude: 10 feet

Owner: U. S. Navy Department

Driller: John B. Rulon

	Thickness (feet)	Depth (feet)
Recent deposits		
Fill, sandy	5	5
Recent and Pleistocene deposits (undifferentiated)		
Mud	73	78
Raritan formation		
Upper Clay member		
Clay, red	6	84
Clay, white	5	89
Middle clay member		
Clay, red	14	103
Sayreville sand member		
Sand, fine	12	115
Clay, sandy	3	118
Sand	10	128
Lower clay member		
Clay, white and red	4	132
Clay, red	40	172
Clay, red and white	10	182
Clay, gray, hard	7	189
Farrington sand member		
Sand, hard	11	200
Gravel	10	210
Sand, white, and clay, gravelly	6	216
Gravel	9	225
Sand and gravel	4	229
Sand, white	2	231
Sand and gravel	14	245
Sand and gravel, fine	7	252
Crystalline rocks		
Sand, micaceous	7	259
Mica schist, soft	15	274

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Well Ph-20

Altitude: 13 feet

Owner: U. S. Navy Department

Driller: John B. Rulon

	Thickness (feet)	Depth (feet)
Recent deposits		
Fill	12	12
Mud	31	43
Pleistocene deposits		
Sand and gravel, fine	13	56
Raritan formation		
Upper clay member		
Clay, white	4	60
Clay, red	4	64
Clay, gray	14	78
Old Bridge sand member		
Sand, fine	8	86
Gravel	2	88
Middle clay member		
Clay, red	22	110
Clay, gray, hard	15	125
Sayreville sand member		
Sand, fine, hard	13	138
Lower clay member		
Clay, gray	5	143
Clay, red	11	154
Farrington sand member		
Sand, fine	20	174
Sand and gravel	11	185
Clay, sandy	5	190
Sand, hard	20	210
Clay, white	1	211
Sand and gravel	16	227
Gravel	14	241
Crystalline rocks		
Clay, white, sandy	6	247
Mica schist	19	266

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Well Ph-22

Altitude: 10 feet

Owner: U. S. Navy Department

Driller: Artesian Well Drilling Company

	Thickness (feet)	Depth (feet)
Recent deposits		
Cinders and fill	4	4
Silt, blue	60	64
Pleistocene deposits		
Clay, sand, and gravel	1	65
Gravel, heavy	7	72
Raritan formation		
Middle clay member and Lower clay member		
Clay, red	11	83
Clay, red and gray	14	97
Clay, red and gray with mica sand	1	98
Crystalline rocks		
Sand, micaceous, with some red and gray clay	5	103
Mica schist, white above and greenish below	24	127

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Well Ph-68

Altitude: 29 feet

Owner: Atlantic Refining Company

	Thickness (feet)	Depth (feet)
Recent deposits		
Fill	3	3
Clay, sandy	6	9
Pleistocene deposits		
Gravel	10	19
Gravel and fine sand	3	22
Raritan formation		
Old Bridge sand member		
Sand, red	8	30
Sand, coarse	3	33
Sand, fine	2	35
Sand and gravel	4	39
Middle clay member and Lower clay member		
Clay, blue	2	41
Clay, sandy	24	65
Farrington sand member		
Sand, coarse	10	75
Sand, fine, and clay	6	81
Sand, fine	3	84
Graved, medium	10	94
Crystalline rocks		
Clay, sandy	1	95
Rock	5	100

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania--Continued

Well Bk-566

Altitude: 15 feet

Owner: Bristol Borough Water Department

Driller: Artesian Well Drilling Company

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, gray, and gravel	7	7
Sand, reddish-brown, fine; coarse gravel	9	16
Sand, yellowish-brown, angular to subangular, medium to fine	8	24
Sand, grayish-yellow	8	32
Crystalline rocks		
Sand, white, and clay	6	38

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Well Bk-676

Altitude: 10 feet

Owner: U. S. Steel Company

Driller: Ranney Method Water Supplies

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, gray, very fine	25	25
Sand, fine to coarse; gravel	11	36
Magothy (?) formation See text, p. 102		
Sand, gray, medium to coarse; plant remains	10	46
Raritan formation		
Upper clay member		
Clay, gray, silty	2	48
Old Bridge sand member		
Sand, grayish-yellow, angular to subangular, medium; some gray clay	34	82
Middle clay member		
Clay, red and gray	32	114
Lignite	2	116
Sayreville sand member		
Sand, light gray, angular to subangular, very coarse	16	132
Crystalline rocks		
Mica schist	81	213

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Well Bk-678

Altitude: 7 feet

Owner: U. S. Steel Company

Driller: Ranney Method Water Supplies

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand and gravel	40	40
Raritan formation		
Old Bridge sand member		
Gravel, fine, with yellow-brown stains	15	55
Middle clay member		
Clay, red	38	93
Sand, white, fine; considerable white clay	6	99
Lignite	2	101
Sayreville sand member		
Sand, white, angular, coarse	36	137
Crystalline rocks		
Schist	.....	137

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Test Hole B-169

Altitude: 15 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, brownish-gray, coarse; gravel	34	34
Raritan formation		
Middle clay member		
Clay	10	44
Sayreville sand member		
Sand, gray to cream, medium to coarse	20	64
Crystalline rocks		
No sample	20	84

Test Hole B-170

Altitude: 20 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Silt, dark brown	4	4
Sand, brown, medium; gravel	6	10
Sand, brown, medium; fine gravel	4	14
Sand, brownish-gray, very coarse; fine gravel	4	18
Sand, very coarse; gravel	20	38
Raritan formation		
Sayreville sand member		
Sand, cream, clayey, very fine	16	54
Crystalline rocks		
Mica schist	23	77

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Test hole B-171

Altitude: 15 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, brown, coarse; gravel	8	8
Gravel, fine	6	14
Raritan formation		
Old Bridge sand member		
Sand, gray, clayey, very fine	24	38
Middle clay member		
No sample	10	48
Sayreville sand member		
Sand, cream, clayey, very fine	20	68
Crystalline rocks		
Clay, white	16	84

Test hole B-174

Altitude: 10 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, grayish-brown, medium	4	4
Silt, dark brown	20	24
Sand, brown, medium to coarse	10	34
Raritan formation		
Middle clay member		
Clay, red	34	68
Sayreville sand member		
Sand, grayish-brown, medium to coarse	16	84

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Test hole B-175

Altitude: 10 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, brown, very fine; silt	4	4
Sand, coarse, and coarse gravel	4	8
Sand, and fine gravel	10	18
Sand, yellowish-brown, coarse; fine gravel	18	36
Raritan formation		
Middle clay member		
Clay, red	25	61
Sayreville sand member		
No sample (easy drilling indicates sand section)	23	84
Lower clay member		
Clay, gray	......	84

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Test hole B-176

Altitude: 10 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, grayish-brown, coarse; gravel	8	8
Raritan formation		
Old Bridge sand member		
Sand, yellowish-brown, angular, medium to coarse	36	44
Sand, yellowish-brown, angular, very coarse	4	48
Middle clay member		
No sample	6	54
Sayreville sand member		
Sand, yellowish-brown, medium to coarse	25	79
Crystalline rocks		
Clay, gray	5	84

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Test hole B-178

Altitude: 20 feet

	Thickness (feet)	Depth (feet)
Recent deposits		
Silt, brown, and fine sand	4	4
Sand, grayish-brown; gravel	14	18
Sand, brownish-gray, medium to very coarse	16	34
Raritan formation		
Middle clay member		
No sample (hard drilling indicates hard clay section)	10	44
Sayreville sand member		
No sample (easy drilling indicates sand section)	20	64
Crystalline rocks		
Mica schist	20	84

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Test hole B-188

Altitude: 35 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand and gravel	8	8
Sand, grayish-brown, subangular, medium to coarse	18	26
Crystalline rocks		
No sample	......	26

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Test hole B-189

Altitude: 20 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, gray, and gravel	12	12
Crystalline rocks		
No Sample	2	14

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Test hole B-192

Altitude: 25 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, very coarse; gravel	14	14
Raritan formation		
Old Bridge sand member		
Sand, cream, clayey, subangular to subrounded, very coarse	10	24
Gravel, fine; very coarse sand	10	34
Middle clay member		
No sample (hard drilling indicates clay section)	14	48
Sayreville sand member		
No sample (easy drilling indicates sand section)	20	68
Crystalline rocks		
Gneiss	7	75

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Test hole B-195

Altitude: 15 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, yellowish-gray, subangular to rounded, coarse; fine gravel	12	12
Raritan formation		
Middle clay member		
Clay, red, and fine white sand	12	24
Sayreville sand member		
Sand, white, angular, fine to coarse	60	84
Crystalline rocks		
No sample	.....	84

Test hole B-196

Altitude: 20 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, brownish-gray, coarse; gravel	7	7
Crystalline rocks		
No sample	.....	7

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Test hole B-198

Altitude: 15 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, gray, coarse; gravel	34	34
Sand, yellowish-gray; gravel	20	54
Raritan formation		
Old Bridge sand member		
Sand, light gray, angular, fine to coarse	26	80
Crystalline rocks		
Clay, light gray	4	84

Test hole B-207

Altitude: 20 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, brownish-gray, medium to coarse; coarse gravel	14	14
Sand, brownish-gray, medium to coarse	16	30
Gravel, fine	6	36
Crystalline rocks		
No sample	......	36

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Test hole B-208

Altitude: 45 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, dark brown, medium to coarse; gravel	15	15
Crystalline rocks		
No sample	.....	15

Test hole B-209

Altitude: 50 feet

	Thickness (feet)	Depth (feet)
Recent deposits		
Silt, dark gray	14	14
Sand, gray, medium; silt	13	27
Clay, gray, silty	16	43
Crystalline rocks		
Mica schist, green	.....	43

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Test hole B-210

Altitude: 15 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand and gravel	18	18
Sand and fine gravel	10	28
Crystalline rocks		
No sample	.....	28

Test hole B-211

Altitude: 20 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, reddish-brown, medium to coarse	14	14
Raritan formation		
Upper clay member		
Clay, gray	6	20
Old Bridge sand member		
Sand, gray, medium to coarse	24	44
Crystalline rocks		
No sample	.....	44

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Test hole B-212

Altitude: 40 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, dark brown; gravel	4	4
Raritan formation		
Sand, yellow, angular to subangular, medium	4	8
Sand, cream to white, subangular to angular, medium	10	18
Sand, cream to white, subangular to angular, medium to coarse	10	28
Sand, cream to white, subangular to angular, medium to very coarse	10	38
Sand, cream to white, subangular to angular, very coarse	6	44
Sand, brownish-gray, angular to subangular, medium to coarse	8	52
Sand, yellowish cream to white, medium to coarse	28	80
Sand, white, coarse to very coarse	28	108
Gravel, very fine	10	118
Crystalline rocks		
Mica schist	6	124

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Test hole B-213

Altitude: 40 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, dark brown, and gravel	10	10
Raritan formation		
Old Bridge sand member		
Sand, cream, angular, medium	5	15
Sand, yellowish-brown, angular, medium	30	45
Middle clay member		
Clay, gray	5	50

Test hole B-226

Altitude: 20 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, brown, and gravel	13	13
Crystalline rocks		
No sample	......	13

Table 13—Sample logs of wells and borings in the Coastal Plain area of southeastern Pennsylvania—Continued

Test hole B-244

Altitude: 40 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Sand, gray, angular to rounded, fine	8	8
Silt, brown to gray; very fine sand	20	28
Crystalline rocks		
No sample	7	35

Test hole B-251

Altitude: 18 feet

	Thickness (feet)	Depth (feet)
Pleistocene deposits		
Silt, brown, and fine sand	24	24
Raritan formation		
Upper clay member		
Clay	10	34
Old Bridge sand member		
Sand, medium to very coarse	4	38
Sand	36	74
Middle clay member		
Clay	10	84

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania

Well number	Ph-5	Ph-6	Ph-7	Ph-11
Source of log	Layne-New York	Layne-New York	Layne-New York	Layne-New York
Altitude (msl)	15 feet	10 feet	12 feet	10 feet
Total depth (feet)	203	190	228	237
Recent (undifferentiated)	0-42 feet: fill and fine to medium dark brown sand.	0-30 feet: mud and silt.	0-65 feet: fine muddy sand, and sandy clay.	0-20 feet: fill, mud, and sand.
Pleistocene (undifferentiated)	42-64 feet: coarse dark gray sand.	30-65 feet: sand, gravel, and boulders.	65-95 feet: sand and boulders.	20-40 feet: gray sand and boulders.
Raritan formation: Upper clay member	64-139 feet[4].			40-125 feet[4]: clay and sand.
Raritan formation: Old Bridge sand member		65-100 feet: sand and some clay; sand and gravel.		
Raritan formation: Middle clay member		100-130 feet[2]: red clay.	95-128 feet: red clay.	
Raritan formation: Sayreville sand member			128-159 feet: coarse sand and some clay.	
Raritan formation: Lower clay member			159-187 feet: tough clay.	125-154 feet: red clay.
Raritan formation: Farrington sand member	139-183 feet: coarse gray sand.	130-163 feet: sand and gravel.	187-204 feet: coarse sand.	154-215 feet: coarse sand and fine gravel
Crystalline rocks	183-203 feet: mica rock.	163-190 feet: mica, sand, and clay.	204-228 feet: soft and tough sandy clay, and mica rock.	215-237 feet: residual clay, mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number	Ph-12	Ph-13	Ph-14	Ph-15
Source of log	Layne-New York	Layne-New York	Layne-New York	Layne-New York
Altitude (msl)	10 feet	12 feet	11 feet	12 feet
Total depth (feet)	110	73	91	82
Recent (undifferentiated)	0-33 feet: blue clay, sand, and gravel.	0-32 feet: brown sand, gravel, and blue clay.	0-49 feet: fill and river mud.	0-40 feet: fill and river mud.
Pleistocene (undifferentiated)	33-72 feet: sand, gravel, and clay.	32-63 feet: medium to coarse sand and gravel.		40-54 feet: gray sand, gravel, and boulders.
Raritan formation: Upper clay member	72-78 feet: white and yellow clay.	63-73 feet: tough red clay.	49-67 feet: soft white clay.	54-59 feet: blue clay.
Raritan formation: Old Bridge sand member	78-103 feet: coarse sand and clay.		67-72 feet: coarse hard sand.	59-77 feet: coarse sand and gravel.
Raritan formation: Middle clay member	103-110 feet: white clay.		72-91 feet: red clay.	77-82 feet: red clay.
Raritan formation: Sayreville sand member				
Raritan formation: Lower clay member				
Raritan formation: Farrington sand member				
Crystalline rocks				

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

	Well Number	Ph-16	Ph-17	Ph-18	Ph-23
	Source of log	Layne-New York	Layne-New York	John B. Rulon	J. Conlan
	Altitude (msl)	11 feet	11 feet	13 feet	10 feet
	Total depth (feet)	84	73	218	600
	Recent (undifferentiated)	0-42 feet: fill and river mud.	0-28 feet: fill and river mud.	0-28 feet: mud, sand, and gravel.	0-19 feet: alluvium and mud.
	Pleistocene (undifferentiated)	42-63 feet: coarse gray sand, gravel, and boulders.	28-55 feet: coarse gravel and boulders.	28-60 feet: sand and gravel.	19-55 feet: fine to coarse gravel.
Raritan formation	Upper clay member	63-84 feet: red clay.	55-73 feet: red clay.	60-68 feet: white clay and sand and gravel.	55-66 feet: bluish white clay and coarse sand and gravel.
Raritan formation	Old Bridge sand member			68-89 feet: fine sand and gravel.	66-83 feet: sand and gravel.
Raritan formation	Middle clay member			89-109 feet: white and gray sandy clay.	83-140 feet: red, white tough sandy clay.
Raritan formation	Sayreville sand member			109-123 feet: white sand and gravel, and little white clay.	140-162 feet: white medium sand and coarse gravel.
Raritan formation	Lower clay member			123-151 feet: red, blue, and gray clay.	162-178 feet: white clay.
Raritan formation	Farrington sand member			151-211 feet: sand and gravel, and a little white clay.	178-245 feet: fine to coarse yellowish white sand, gravel, and cobbles.
	Crystalline rocks			211-218 feet: white sandy clay and mica schist.	245-600 feet: very clayey yellowish sand and gray micaceous rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

	Well number	Ph-24	Ph-28	Ph-30	Ph-32
	Source of log	T. B. Harper	Schultes & Sons	Layne-New York	Phila. Gas Co.
	Altitude (msl)	10 feet	10 feet	12 feet	28 feet
	Total depth (feet)	906	250	198	96
	Recent (undifferentiated)	0-20 feet: mud.	0-30 feet: fill and black clay.	0-26 feet: black mud and fine silty sand.	
	Pleistocene (undifferentiated)	20-79 feet: fine brown sand and coarse gravel.	30-55 feet: fine gray and yellow sand and boulders.	26-55 feet: brown sand and gravel and clay.	0-50 feet: sand and gravel.
Raritan formation	Upper clay member			55-59 feet: sandy clay.	
	Old Bridge sand member		55-81 feet: sand and gravel.	59-77 feet: fine brown sand and gravel.	
	Middle clay member	79-135 feet: red clay.	81-110 feet[4]: sand and gravel and clay.	77-94 feet: red and white sandy clay.	50-66 feet[2]: clay.
	Sayreville sand member	135-145 feet: coarse sand and fine gravel.		94-138 feet: brown and gray coarse sand and little clay.	66-96 feet: white sand and gravel.
	Lower clay member	145-190 feet: red sandy clay.	110-146 feet: red and gray clay.	138-152 feet: clay and boulders.	
	Farrington sand member	190-250 feet: gray coarse sand and fine gravel and white clay.	146-215 feet: sand and gravel.	152-182 feet: sand, gravel, and boulders.	
	Crystalline rocks	250-906 feet: white sandy clay and micaceous rock.	215-250 feet: weathered rock.	182-198 feet: tough clay and mica rock.	

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		Ph-33	Ph-35	Ph-36	Ph-37
Well number		Ph-33	Ph-35	Ph-36	Ph-37
Source of log		Ridpath & Potter	Sprague & Henwood	Sprague & Henwood	John B. Rulon
Altitude (msl)		11 feet	17 feet	21 feet	17 feet
Total depth (feet)		100	106	81	90
Recent (undifferentiated)		0-16 feet: fill, mud, and gravel.	0-56 feet: fill and clay.	0-70 feet: fill and gray and brown clay.	0-67 feet: fill and gray and brown clay
Pleistocene (undifferentiated)		16-41 feet: coarse sand, gravel, and clay.	56-83 feet: fine brown sand and fine gravel.		67-74 feet: gravel and small stones.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member	41-58 feet[2]: red and white clay.			
	Sayreville sand member				
	Lower clay member				
	Farrington sand member	58-91 feet: yellow sand and gravel.	83-86 feet: white coarse sand.	70-77 feet: brown sand.	74-87 feet: brown sand and gravel and little yellow clay.
Crystalline rocks		91-100 feet: white clay and schist rock.	86-106 feet: dark mica rock.	77-81 feet: mica rock.	87-90 feet: white soft rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number		Ph-38	Ph-39	Ph-40	Ph-41
Source of log		Sprague & Henwood	Sprague & Henwood	John B. Rulon	Gulf Oil Corp.
Altitude (msl)		16 feet	17 feet	17 feet	19 feet
Total depth (feet)		90	73	79	70
Recent (undifferentiated)		0-69 feet; fill and blue clay.	0-59 feet: soil and blue clay.	0-41 feet: fill and clay.	0-42 feet: fill, mud, and clay.
Pleistocene (undifferentiated)		69-78 feet: coarse brown sand and brown gravel.	59-66 feet: purple sand and gravel.	41-64 feet: purple sand, gravel, and small stones.	42-57 feet: sand and gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member				
	Sayreville sand member				
	Lower clay member				
	Farrington sand member	78-84 feet: white sand and gravel.	66-70 feet: white sand and gravel.	64-77 feet: light sand, gravel, and stones.	57-68 feet: brown sand and gravel.
Crystalline rocks		84-90 feet: white mica rock.	70-73 feet: rock.	77-79 feet: mica rock.	68-70 feet: bedrock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number		Ph-42	Ph-50	Ph-55	Ph-61
Source of log		John B. Rulon	Layne-New York	T. B. Harper	Artesian Well Co.
Altitude (msl)		16 feet	27 feet	33 feet	15 feet
Total depth (feet)		108	117	232	199
Recent (undifferentiated)		0-45 feet: fill, river mud, and clays.	0-80 feet[3]: buff clay and some sand and gravel.	0-25 feet: yellow clay.	0-20 feet: fill and blue clay.
Pleistocene (undifferentiated)		45-46 feet: coarse gravel.		25-30 feet: yellow clay and gravel.	20-41 feet: coarse gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member	46-60 feet: sand and fine gravel.			41-73 feet: fine white sand.
	Middle clay member		80-89 feet[2]: dense blue clay.	30-55 feet[2]: reddish yellow and dark clay and little gravel.	73-84 feet: red and white clay.
	Sayreville sand member				84-93 feet: coarse yellow sand and gravel.
	Lower clay member				93-115 feet: tough red clay.
	Farrington sand member	60-85 feet: white sand and gravel capped by brown sand.	89-102 feet: white angular gravel.	55-90 feet: yellowish white gravel.	115-179 feet: medium to coarse gravel.
Crystalline rocks		85-108 feet: clay and mica rock.	102-117 feet: feldspathic fragments, mica, and quartz; mica schist.	90-232 feet: mica rock.	179-199 feet: mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number		Ph-64	Ph-69	Ph-73	Ph-74
Source of log		Artesian Well Co.	Atlantic Refining	Atlantic Refining	Atlantic Refining
Altitude (msl)		15 feet	31 feet	16 feet	11 feet
Total depth (feet)		184	104	607	503
Recent (undifferentiated)		0-20 feet: fill.	0-14 feet: fill and clay.	0-50 feet: sandy blue clay.	0-34 feet: fill, mud and sandy clay.
Pleistocene (undifferentiated)		20-72 feet: sand.	14-35 feet: sand and gravel.	50-68 feet: sand and gravel.	34-66 feet: yellow and red sandy gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member	72-86 feet: clay.	35-73 feet[2]: sandy clay.	68-70 feet[2]: sandy clay.	
	Sayreville sand member	86-94 feet: sand and gravel.			
	Lower clay member	94-118 feet: clay.			
	Farrington sand member	118-180 feet: sand and gravel.	73-100 feet: sand and gravel.	70-73 feet: coarse sand.	
Crystalline rocks		180-184 feet: rock.	100-104 feet: rock.	73-607 feet: blue clay and rock.	66-503 feet: blue sandy clay and rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number		Ph-75	Ph-80	Ph-82	Ph-83
Source of log		Atlantic Refining	Artesian Well Co.	Atlantic Refining	Ridpath & Potter
Altitude (msl)		18 feet	33 feet	12 feet	14 feet
Total depth (feet)		101	150	68	77
Recent (undifferentiated)		0-49 feet: fill, clay, and gravel.	0-70 feet	0-37 feet: clay, silt, and fine sand.	0-25 feet: fill and river mud.
Pleistocene (undifferentiated)		49-76 feet: sand and gravel.	70-77 feet: sand and fine gravel.	37-67 feet: coarse sand and gravel, little clay.	25-30 feet: gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member		77-86 feet[2]: mud.		30-50 feet[2]: red clay.
	Sayreville sand member				
	Lower clay member				
	Farrington sand member		86-98 feet: sand and fine to coarse gravel.		50-77 feet: fine sand, and fine to coarse gravel.
Crystalline rocks		76-101 feet: blue clay and rock.	98-150 feet: rock.	67-68 feet: blue clay.	

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

	Well number	Ph-85	Ph-86	Ph-92	Ph-94
	Source of log	Layne-New York	Layne-New York	Artesian Well Co.	Artesian Well Co.
	Altitude (msl)	14 feet	14 feet	31 feet	13 feet
	Total depth (feet)	147	151	100	65
	Recent (undifferentiated)	0-20 feet: fill and river mud.	0-10 feet: top soil.	0-34 feet: fill, loam, and clay.	0-13 feet: fill.
	Pleistocene (undifferentiated)	21-41 feet: sand and boulders.	10-21 feet: boulders and sand.	34-37 feet: gravel.	13-29 feet: gravel and clay.
Raritan formation	Upper clay member	41-60 feet: soft red clay.	21-31 feet: clay.		
Raritan formation	Old Bridge sand member	60-64 feet: coarse sand.	31-64 feet: sand, clay, and gravel.		
Raritan formation	Middle clay member	64-96 feet[2]: red tough clay.	64-96 feet[2]: red tough clay.	37-54 feet[2]: clay.	29-30 feet[2]: clay.
Raritan formation	Sayreville sand member				
Raritan formation	Lower clay member				
Raritan formation	Farrington sand member	96-140 feet: coarse sand, gravel, boulders, and clay.	96-143 feet: sand, gravel, and some clay.	54-75 feet: sand and gravel.	30-55 feet: coarse sand and gravel.
	Crystalline rocks	140-147 feet: mica rock.	143-151 feet: mica rock.	75-100 feet: rock.	55-65 feet: mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		Ph-96	Ph-108	Ph-112	Ph-113
Well number		Ph-96	Ph-108	Ph-112	Ph-113
Source of log		Layne-New York	Layne-New York	Layne-New York	Layne-New York
Altitude (msl)		40 feet	35 feet	38 feet	38 feet
Total depth (feet)		78	127	69	71
Recent (undifferentiated)		0-34 feet: fill and yellow clay.	0-4 feet: clay	0-10 feet: clay.	0-20 feet: river clay and sand.
Pleistocene (undifferentiated)		34-51 feet: gravel sand and clay.	4-84 feet: sand gravel, and some clay.	10-43 feet: clay sand, and gravel.	20-44 feet: gravel, sand, and clay.
Raritan formation	Upper clay member		84-87 feet: clay.		
	Old Bridge sand member		87-98 feet: packed sand and gravel.		
	Middle clay member	51-73 feet[2]: red, yellow sandy micaceous clay.	98-105 feet[2]: clay.		
	Sayreville sand member				
	Lower clay member				
	Farrington sand member		105-111 feet: packed sand and gravel.		
Crystalline rocks		73-78 feet: rock.	111-127 feet: sandy clay and mica.	43-69 feet: residual clay and rock.	44-71 feet: residual clay and rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

	Well number	Ph-114	Ph-139	Ph-140	Ph-141
	Source of log	Layne-New York	Layne-New York	Layne-New York	Ridpath & Potter
	Altitude (msl)	30 feet	20 feet	20 feet	10 feet
	Total depth (feet)	56	186	193	185
	Recent (undifferentiated)	0-20 feet: river mud.	0-35 feet: cinders and blue river mud.	0-35 feet: cinders and blue river mud.	0-45 feet: fill and gray river mud.
	Pleistocene (undifferentiated)	20-46 feet: sand, gravel, and clay.	35-60 feet: sand gravel, and boulders and little clay.	35-60 feet: clay, sand, and gravel, and boulders.	45-73 feet: fine to coarse sand and gravel.
Raritan formation	Upper clay member		60-70 feet: clay, gravel, and boulders.	60-70 feet: clay and boulders.	
	Old Bridge sand member		70-74 feet: coarse sand and gravel.	70-80 feet: sand and gravel.	
	Middle clay member		74-104 feet: white, blue, and red clay.	80-100 feet: white and blue clay.	73-105 feet: red clay.
	Sayreville sand member		104-121 feet: fine sand and little clay.	100-112 feet: coarse sand.	105-107 feet: fine sand and gravel.
	Lower clay member		121-154 feet: red, blue, white, and yellow clay; little sand.	112-158 feet: tough red sandy clay and sand lens.	107-131 feet: red clay.
	Farrington sand member		154-183 feet: coarse white and yellow sand and gravel.	158-182 feet: coarse sand and gravel and little clay.	131-185 feet: coarse sand and heavy gravel.
	Crystalline rocks	46-56 feet: mica, clay, and mica rock.	183-186 feet: white sandy clay.	182-193 feet: residual clay and rock.	185 feet: white clay, residual bedrock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

	Well number	Ph-143	Ph-144	Ph-152	Ph-153
	Source of log	Layne-New York	Layne-New York	Layne-New York	Ridpath & Potter
	Altitude (msl)	10 feet	11 feet	10 feet	10 feet
	Total depth (feet)	185	185	237	200
	Recent (undifferentiated)	0-34 feet: clay and mud.	0-34 feet: clay.	0-61 feet: blue clay and little coarse sand.	0-34 feet: blue clay and fine gray sand.
	Pleistocene (undifferentiated)	34-69 feet: sand, gravel, and boulders.	34-69 feet: sand, gravel, and boulders.	61-82 feet: coarse sand and gravel.	34-97 feet: fine sand and coarse gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member	69-133 feet[2]: red and blue clay.	69-133 feet[2]: red, white, blue, and yellow clay.	82-142 feet: red clay.	97-107 feet: yellow clay.
	Sayreville sand member			142-146 feet: sand and gravel.	107-117 feet: yellow sand.
	Lower clay member			146-158 feet: sandy and tough clay.	117-132 feet: red and gray clay.
	Farrington sand member	133-160 feet: sand, coarse gravel, and some white clay.	133-165 feet: sand, coarse gravel, and some white clay.	158-219 feet: sand and gravel with stringer of clay.	132-180 feet: white sand and little clay.
	Crystalline rocks	160-185 feet: soft white clay and weathered rock.	165-185: soft white clay and packed sand (residual bedrock).	219-237 feet: residual clay and bedrock.	180-200 feet: mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number		Ph-166	Ph-172	Ph-174	Ph-194
Source of log		Artesian Well Co.	Ridpath & Potter	T. B. Harper	T. B. Harper
Altitude (msl)		22 feet	10 feet	37 feet	35 feet
Total depth (feet)		111	105	576	266
Recent (undifferentiated)		0-9-feet: clayey soil.	0-26 feet: fill and hard yellow clay.		0-20 feet: clay.
Pleistocene (undifferentiated)		9-24 feet: sand and gravel.	26-30 feet: coarse gravel.	0-44 feet: clay and gravel.	20-66 feet: gravel.
Raritan formation	Upper clay member	24-26 feet: brown clay.			
	Old Bridge sand member	26-31 feet: clear white medium sand and gravel.			
	Middle clay member	31-59 feet[2]: red and yellow-brown clay.	30-70 feet[2]: yellow clay.		
	Sayreville sand member				
	Lower clay member				
	Farrington sand member	59-109 feet: fine to coarse sand and gravel.	70-105 feet: fine to coarse sand and gravel and some clay.		
Crystalline rocks		109-111 feet: residual rock, white sand, gravel, and large mica flakes.		44-576 feet: mica schist rock.	66-266 feet: gneiss and mica schist.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number		Ph-240	Ph-248	Ph-249	Ph-275
Source of log		Artesian Well Co.	N. J. Geol. Sur. Annual Report 1891	Cook	Ridpath & Potter
Altitude (msl)		15 feet	15 feet	13 feet	13 feet
Total depth (feet)		155	140	156	400
Recent (undifferentiated)		0-47 feet: loam, sand and gravel, and black clay.	0-75 feet[4]: alluvium and fine yellow sand.	0-47 feet: gravel and blue clay.	0-63 feet: fill and mud and sand.
Pleistocene (undifferentiated)		47-54 feet: gravel.		47-59 feet: sand and gravel and clay.	
Raritan formation	Upper clay member	54-59 feet: yellow clay.			
	Old Bridge sand member	59-63 feet: sand and gravel.			
	Middle clay member	63-76 feet: white clay.		59-87 feet[2]: red clay.	
	Sayreville sand member	76-89 feet: sand.	75-90 feet: fine gray sand.		
	Lower clay member	89-114 feet: red clay.	90-94 feet: fine white clay.		
	Farrington sand member	114-155 feet: sand and gravel and little white clay.	94-140 feet: coarse white sand and gravel.	87-134 feet: white sand and a little clay.	
Crystalline rocks			140 feet: rock.	134-156 feet: Residual blue clay and rock.	63-400 feet: mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

	Well number	Ph-321	Ph-324	Ph-325	Ph-326
	Source of log	Layne-New York	Layne-New York	Layne-New York	Layne-New York
	Altitude (msl)	20 feet	11 feet	10 feet	18 feet
	Total depth (feet)	49	67	80	65
	Recent (undifferentiated)				
	Pleistocene (undifferentiated)	0-49 feet: fine to coarse sand and gravel; little clay.	0-25 feet: sand and gravel.	0-25 feet: sand and gravel.	0-25 feet: sand and gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member		25-45 feet[2]: yellow and sandy clay.	25-40 feet[2]: yellow and brown clay.	25-45 feet[2]: yellow and red sandy clay.
	Sayreville sand member				
	Lower clay member				
	Farrington sand member		45-65 feet: sand and gravel.	40-60 feet: fine brown sand and gravel.	45-58 feet: brown sand and clay.
	Crystalline rocks	49 feet: mica rock.	65-67 feet: rock	60-80 feet: mica rock.	58-65 feet: mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number		Ph-327	Ph-357	Ph-361	Ph-372
Source of log		Layne-New York	W. Stothoff	Ridpath & Potter	Ridpath & Potter
Altitude (msl)		10 feet	20 feet	10 feet	10 feet
Total depth (feet)		44	201	35	40
Recent (undifferentiated)				0-15 feet: cinders and river mud.	
Pleistocene (undifferentiated)		0-19 feet: sand and gravel.	0-31 feet: sand, clay, and boulders.	15-25 feet: sand and gravel.	0-20 feet: coarse gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member	19-38 feet[2]: yellow sandy clay.		25-26 feet[2]: fine sandy clay.	
	Sayreville sand member				
	Lower clay member				
	Farrington sand member	38-43 feet: coarse sand and gravel.		26-35 feet: sand and gravel.	20-35 feet; fine gravel.
Crystalline rocks		43-44 feet: residual yellow clay and mica.	31-201 feet: granite rock.		35-40 feet: mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number		Ph-389	Ph-407	Ph-411	Ph-412
Source of log		John B. Rulon	Layne-New York	Layne-New York	Layne-New York
Altitude (msl)		10 feet	8 feet	10 feet	10 feet
Total depth (feet)		55	196	87	96
Recent (undifferentiated)		0-34 feet: clay, dirty sand, and gravel.	0-50 feet: filling and river mud.	0-53 feet: fill and sandy blue clay.	0-57 feet: fill and river mud, and clay.
Pleistocene (undifferentiated)		34-55 feet: sand and gravel.	50-75 feet: fine to coarse sand and gravel.	53-70 feet: sand and gravel.	57-71 feet: sand and gravel.
Raritan formation	Upper clay member		75-80 feet: sandy clay.		71-72 feet: clay.
	Old Bridge sand member		80-90 feet: sand and clay.	70-85 feet: yellow sand.	72-89 feet: medium sand.
	Middle clay member		90-147 feet[2]: white and red clay.	85-87 feet: red clay.	89-96 feet: red clay.
	Sayreville sand member				
	Lower clay member				
	Farrington sand member		147-188 feet: white sand.		
Crystalline rocks		55 feet: mica rock.	188-196 feet: mica and clay.		

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number		Ph-413	Ph-414	Ph-416	Ph-417
Source of log		Layne-New York	Layne-New York	Layne-New York	Layne-New York
Altitude (msl)		10 feet	10 feet	10 feet	9 feet
Total depth (feet)		80	87	90	172
Recent (undifferentiated)		0-46 feet. fill and river mud.	0-46 feet: fill and blue silty clay.	0-44 feet: fill and river mud.	0-36 feet: fill and river mud.
Pleistocene (undifferentiated)		46-70 feet: coarse sand and coarse gravel.	46-83 feet: coarse sand and gravel.	44-66 feet: gray sand and coarse gravel.	36-82 feet: coarse sand and gravel and some clay.
Raritan formation	Upper clay member				
	Old Bridge sand member	70-76 feet: gray and yellow sand and gravel.		66-90 feet: white and yellow sand and gravel.	
	Middle clay member	76-80 feet: red clay.	83-87 feet: white sandy clay.		82-142 feet[2]: red and white clay with 2 thin gravel stringers.
	Sayreville sand member				
	Lower clay member				
	Farrington sand member				142-158 feet: medium to coarse sand and fine gravel.
Crystalline rocks					158-172 feet: mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number	Ph-418	Ph-419	Ph-420	Ph-423
Source of log	Layne-New York	Layne-New York	Layne-New York	Layne-New York
Altitude (msl)	10 feet	9 feet	8 feet	10 feet
Total depth (feet)	155	167	171	192
Recent (undifferentiated)	0-55 feet: fill, river mud, and sand.	0-28 feet: fill and river silt.	0-40 feet: river mud and fill.	0-64 feet: clay and some sand and gravel.
Pleistocene (undifferentiated)	55-67 feet: gray sand and boulders.	28-86 feet: fine sand and gravel.	40-67 feet: gray sand and gravel.	64-74 feet: coarse gravel.
Raritan formation: Upper clay member	67-70 feet: clay.		67-71 feet: clay and gravel.	74-82 feet: clay.
Raritan formation: Old Bridge sand member	70-75 feet: coarse white sand and boulders.		71-90 feet: gray and brown sand.	82-112 feet: sand and gravel.
Raritan formation: Middle clay member	75-123 feet[2]: tough red clay.	86-133 feet[2]: red clay.	90-139 feet[2]: red and white clay.	112-124 feet: clay.
Raritan formation: Sayreville sand member				124-144 feet: sand and gravel and some clay.
Raritan formation: Lower clay member				144-169 feet: clay.
Raritan formation: Farrington sand member	123-144 feet: coarse gray sand.	133-150 feet: coarse sand and gravel.	139-168 feet: fine to coarse white and gray sand and gravel.	169-186 feet: sand and gravel.
Crystalline rocks	144-155 feet: residual clay and mica rock.	150-167 feet: rock.	168-171 feet: rock.	186-192 feet: mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number	Ph-426	Ph-430	Ph-434	Ph-447
Source of log	John B. Rulon	Layne-New York	Artesian Well Co.	Regal Petroleum
Altitude (msl)	10 feet	10 feet	11 feet	20 feet
Total depth (feet)	178	160	168	351
Recent (undifferentiated)	0-36 feet: river mud.	0-25 feet: fill and river mud.	0-20 feet: fill.	0-20 feet: fill.
Pleistocene (undifferentiated)	36-74 feet: sand and gravel.	25-53 feet: coarse sand and boulders.	20-65 feet: sand and coarse gravel.	
Raritan formation: Upper clay member				
Raritan formation: Old Bridge sand member				
Raritan formation: Middle clay member	74-130 feet[2]: red and some white and gray clay.	53-100 feet[2]: red and blue clay.	65-93 feet: white and red clay.	
Raritan formation: Sayreville sand member			93-99 feet: fine red sand.	
Raritan formation: Lower clay member			99-129 feet: red clay.	
Raritan formation: Farrington sand member	130-178 feet: sand and gravel and a little white clay.	100-136 feet: gray and white coarse sand and boulders.	129-168 feet: coarse sand and gravel.	
Crystalline rocks	178 feet: rock.	136-160 feet: mica rock.		20-351 feet: mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		Ph-451	Ph-452	Ph-457	Ph-458
Well number		Ph-451	Ph-452	Ph-457	Ph-458
Source of log		Layne-New York	Layne-New York	Layne-New York	Layne-New York
Altitude (msl)		11 feet	11 feet	11 feet	11 feet
Total depth (feet)		170	164	152	168
Recent (undifferentiated)		0-20 feet: fill and river mud	O-24 feet: fill and river mud.	0-25 feet: fill and river mud	0-35 feet: fill and river mud.
Pleistocene (undifferentiated)		20-50 feet: sand, gravel, and clay.	24-50 feet: sand, gravel, and boulders; little clay.	25-50 feet: coarse gray sand.	35-66 feet: sand and boulders.
Raritan formation	Upper clay member				
	Old Bridge sand member	50-68 feet: medium sand.	50-69 feet: coarse gray sand.		
	Middle clay member	68-83 feet: clay.	69-114 feet[2]: clay.	50-110 feet[2]: red and white sandy clay.	66-121 feet[2]: red clay.
	Sayreville sand member	83-104 feet: sand and clay.			
	Lower clay member	104-121 feet: sandy clay.			
	Farrington sand member	121-156 feet: medium to coarse sand and gravel.	114-164 feet: sand, gravel, and boulders.	110-137 feet: fine to coarse gray sand and gravel.	121-152 feet: medium to coarse sand.
Crystalline rocks		156-170 feet: coarse sand and mica. (Rock residual)		137-152 feet: clay and mica rock.	152-168 feet: white clay and mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

	Well number	Ph-459	Ph-469	Ph-728	Ph-730
	Source of log	Layne-New York	Layne-New York	N. J. Geol. Sur. Annual Report 1892	N. J. Geol. Sur. Annual Report 1892
	Altitude (msl)	11 feet	10 feet	14 feet	8 feet.
	Total depth (feet)	160	133	670	98
	Recent (undifferentiated)	0-22 feet: cinder fill and river mud.	0-45 feet: river mud.	0-27 feet: black muck.	0-36 feet: fill and black mud.
	Pleistocene (undifferentiated)	22-64 feet: fine to medium sand and boulders.	45-53 feet: sand and boulders.	27-44 feet: coarse gravel.	36-49 feet: gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member	64-114 feet[2]: red clay.	53-111 feet: tough clay.	44-103 feet[2]: red, yellow, and blue clay.	49-86 feet[2]: red and varied colored clay.
	Sayreville sand member		111-128 feet: coarse sand.		
	Lower clay member		128-133 feet: tough clay.		
	Farrington sand member	114-152 feet: fine to coarse sand and gravel.		103-130 feet: coarse sand and gravel.	86-98 feet: cobble-stone gravel.
	Crystalline rocks	152-162 feet: mica rock.		130-670 feet: residual clay and mica rock.	

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		Ph-731	Ph-732
Well number		Ph-731	Ph-732
Source of log		N. J. Geol. Sur. Annual Report 1896	N. J. Geol. Sur. Annual Report 1894
Altitude (msl)		10 feet	13 feet
Total depth (feet)		456	308
Recent (undifferentiated)		0-147 feet[4].	
Pleistocene (undifferentiated)			0-58 feet: coarse sand and gravel.
Raritan formation	Upper clay member		
	Old Bridge sand member		
	Middle clay member		58-74 feet[2]: red clay.
	Sayreville sand member		
	Lower clay member		
	Farrington sand member	147-208 feet: white sand and gravel.	74-78 feet: gravel.
Crystalline rocks		208-456 feet: mica gneiss.	78-308 feet: bedrock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		Bk-520	Bk-531	Bk-532	Bk-534
Well number		Bk-520	Bk-531	Bk-532	Bk-534
Source of log		Croyden Water Co.	Bristol Boro	Bristol Boro Water Dept.	Bristol Boro Water Dept.
Altitude (msl)		15 feet	20 feet	20 feet	20 feet
Total depth (feet)		41	70	65	64
Recent (undifferentiated)		0-5 feet: loam.			
Pleistocene (undifferentiated)		5-31 feet: gravel.	0-47 feet: gravel and sand.	0-52 feet: brown sand and gravel.	0-46 feet: coarse brown sand and gravel and clay.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member				
	Sayreville sand member		47-64 feet: fine to coarse sand and gravel.	52-59 feet: white sand and gravel.	46-57 feet: very fine white sand and clay.
	Lower clay member				
	Farrington sand member				
Crystalline rocks		31-41 feet: soft rock.	64-70 feet: residual clay bedrock.	59-65 feet: residual clay bedrock.	57-64 feet: white clay.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number		Bk-537	Bk-542	Bk-543	Bk-544
Source of log		Bristol Boro Water Dept.	Rohm & Haas Co.	Rohm & Haas Co.	Rohm & Haas Co.
Altitude (msl)		25 feet	20 feet	20 feet	20 feet
Total depth (feet)		74	110	72	65
Recent (undifferentiated)			0-5 feet: topsoil.		0-7 feet: fill and tough clay.
Pleistocene (undifferentiated)		0-50 feet: coarse sand and gravel.	5-35 feet: brown sand and boulders.	0-35 feet: brown sand, gravel, and clay.	7-40 feet: sand, gravel, and boulders.
Raritan formation	Upper clay member		35-109 feet[4].		
	Old Bridge sand member			35-54 feet: brown, yellow, white, gray, and red sand.	
	Middle clay member			54-57 feet: white and yellow clay.	40-48 feet: red and yellow clay.
	Sayreville sand member			57-62 feet: coarse brown and white sand and gravel.	48-65 feet: yellow sand.
	Lower clay member				
	Farrington sand member				
Crystalline rocks		50-74 feet: gray sandy clay, residual bedrock.	109-110 feet: black mica rock.	62-72 feet: white clay and mica rock.	

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

	Well number	Bk-546	Bk-562	Bk-563	Bk-564
	Source of log	Rohm & Haas Co.	Bristol Boro Water Dept.	Bristol Boro Water Dept.	Bristol Boro Water Dept.
	Altitude (msl)	15 feet	15 feet	15 feet	20 feet
	Total depth (feet)	56	50	50	50
	Recent (undifferentiated)	0-4 feet: topsoil.	0-3 feet: topsoil and fill.	0-6 feet: topsoil and clay.	0-5 feet: topsoil and fill.
	Pleistocene (undifferentiated)	4-38 feet: sand and gravel.	3-24 feet: sand and gravel.	6-27 feet: gravel and sand.	5-25 feet: gravel and sand.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member				
	Sayreville sand member	38-56 feet: coarse yellow sand.			
	Lower clay member				
	Farrington sand member				
	Crystalline rocks		24-50 feet: residual clay bedrock.	27-50 feet: residual clay bedrock.	25-50 feet: residual clay bedrock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number		Bk-567	Bk-568	Bk-569	Bk-570
Source of log		Patterson Parchment Paper Co.	Patterson Parchment Paper Co.	Patterson Parchment Paper Co.	Patterson Parchment Paper Co.
Altitude (msl)		15 feet	15 feet	15 feet	15 feet
Total depth (feet)		78	115	79	82
Recent (undifferentiated)		0-3 feet: topsoil.	0-5 feet: topsoil.	0-3 feet: topsoil.	0-6 feet: topsoil and yellow clay.
Pleistocene (undifferentiated)		3-30 feet: boulder, gravel and yellow clay.	5-38 feet: sand, gravel, and boulders.	3-20 feet: coarse gravel.	6-31 feet: gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member	30-48 feet: yellow sandy clay.	38-73 feet: red, yellow and gray clay.	20-79 feet[4].	31-80 feet[4]: yellow and gray clay.
	Sayreville sand member	48-76 feet: sand and gravel.	73-109 feet[4].		
	Lower clay member				
	Farrington sand member				
Crystalline rocks		76-78 feet: rock.	109-115 feet: white clay and rock.	79 feet: rock.	80-82 feet: rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

	Well number	Bk-571	Bk-589	Bk-614	Bk-616
	Source of log	Patterson Parchment Paper Co.	Lower Bucks Co. Joint Mun. Auth.	Amico Sand and Gravel Co.	Falls Twp. Water and Sewer Auth.
	Altitude (msl)	15 feet	8 feet	40 feet	45 feet
	Total depth (feet)	92	40	70	102
	Recent (undifferentiated)	0-3 feet: topsoil and yellow clay.	0-6 feet: topsoil, sand and clay.		
	Pleistocene (undifferentiated)	3-28 feet: brown sand and gravel.	6-36 feet: sand and gravel.	0-55 feet: sand and gravel.	0-48 feet: sand and gravel.
Raritan formation	Upper clay member				48-51 feet: white clay (fossil soil).
	Old Bridge sand member				51-74 feet: fine sand and gravel.
	Middle clay member	28-55 feet: red, yellow and blue clay.			704-102 feet: red, white, and gray clay.
	Sayreville sand member	55-90 feet: gray sandy clay.			
	Lower clay member				
	Farrington sand member				
	Crystalline rocks	90-92 feet: rock.	36-40 feet: decomposed mica rock.	55-69 feet: mica rock.	

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number		Bk-617	Bk-618	Bk-619	Bk-625
Source of log		Falls Twp. Water and Sewer Auth.	Falls Twp. Water and Sewer Auth.	Falls Twp. Water and Sewer Auth.	Morrisville Boro Water Dept.
Altitude (msl)		45 feet	45 feet	45 feet	20 feet
Total depth (feet)		83	100	100	74
Recent (undifferentiated)					0-2 feet: topsoil.
Pleistocene (undifferentiated)		0-45 feet: sand and gravel.	0-48 feet: fine sand and gravel.	0-18 feet: fine sand and gravel.	2-40 feet: sand, gravel, and boulders.
Raritan formation	Upper clay member		48-51 feet: yellow clay (fossil soil).	18-24 feet: clay.	
	Old Bridge sand member		51-54 feet: sand and gravel.	24-57 feet: fine sand, clay, and gravel.	
	Middle clay member	45-48 feet: white clay.	54-66 feet: yellow clay.	57-69 feet: white clay.	
	Sayreville sand member	48-75 feet: sand and gravel.		69-93 feet: sand and gravel.	
	Lower clay member	75-83 feet: red clay.			
	Farrington sand member				
Crystalline rocks			66-100 feet: clay and rock.	93-100 feet: rock and clay.	40-74 feet: mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number		Bk-626	Bk-627	Bk-628	Bk-629
Source of log		Morrisville Boro Water Dept.	Morrisville Boro Water Dept.	Morrisville Boro Water Dept.	Victor Chemical Co.
Altitude (msl)		25 feet	25 feet	25 feet	20 feet
Total depth (feet)		146	117	175	170
Recent (undifferentiated)			0-3 feet: topsoil.		0-12 feet: topsoil
Pleistocene (undifferentiated)		0-47 feet: sand and gravel.	3-42 feet: sand, gravel, and boulders.	0-42 feet: sand and boulders.	12-70 feet[4]: pea gravel with clay and fine sand.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member	47-68 feet: red and white clay and sand.	42-61 feet: white clay.	42-66 feet: clay and some sand.	
	Sayreville sand member	68-72 feet: gravel.	61-105 feet: white sand and gravel.	66-165 feet[4]: coarse white sand.	70-87 feet: medium fine white sand.
	Lower clay member				87-132 feet: red clay.
	Farrington sand member		105-117 feet: yellow sand and gravel.		132-170 feet: fine white gravel.
Crystalline rocks		72-146 feet: hard residual yellow and white clay and rock.	117 feet: clay (residual bedrock).	165-175 feet: rock.	170 feet: rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

	Well number	Bk-634	Bk-635	Bk-636	Bk-638
	Source of log	King's Farms Co.	King's Farms Co.	King's Farms Co.	Pa. Historical and Museum Commission.
	Altitude (msl)	20 feet	20 feet	20 feet	10 feet
	Total depth (feet)	58	55	67	90
	Recent (undifferentiated)	0-8 feet: soil.	0-8 feet: soil.	0-4 feet: soil.	
	Pleistocene (undifferentiated)	8-18 feet: gravel.	8-18 feet: gravel.	4-17 feet: sand and gravel.	0-47 feet: gravel and sand.
Raritan formation	Upper clay member	18-48 feet[1]: clay.	18-42 feet[1]: clay.	17-42 feet[1]: yellow and white clay.	
	Old Bridge sand member				47-53 feet: sand.
	Middle clay member				53-84 feet: clay.
	Sayreville sand member	48-58 feet: sand.	42-55 feet: sand and gravel.	42-65 feet: yellow sand and gravel.	84-90 feet: sand.
	Lower clay member				
	Farrington sand member				
	Crystalline rocks			65-67 feet: white clay (weathered rock).	90 feet: bedrock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number		Bk-654	Bk-679	Bk-681	Bk-682
Source of log		Phila. Electric Co.	U.S. Steel Co.	U.S. Steel Co.	U.S. Steel Co.
Altitude (msl)		20 feet	5 feet	14 feet	14 feet
Total depth (feet)		71	114	201	146
Recent (undifferentiated)					0-20 feet: topsoil and sandy clay.
Pleistocene (undifferentiated)		0-18 feet: loam and gravel.	0-16 feet: coarse sand, gravel and boulders.	0-55 feet: sandy clay, coarse sand and boulders.	20-54 feet: sand and boulders.
Raritan formation	Upper clay member	18-51 feet: red and white and brown clay.		55-83 feet[4]: white silty sand and clay.	54-65 feet: white clay and yellow sand.
	Old Bridge sand member	51-68 feet: fine white sand and gravel.	16-48 feet: fine to medium white and yellow sand.		65-87 feet: yellow sand.
	Middle clay member		48-102 feet: red and yellow clay.	83-118 feet: red and blue clay, gray sand and clay.	87-121 feet: blue clay, white sand and clay, red clay.
	Sayreville sand member			118-149 feet: fine to coarse yellow sand and gravel.	121-133 feet: light brown sand.
	Lower clay member				
	Farrington sand member				
Crystalline rocks		68-71 feet: white clay and mica rock.	102-114 feet: hard blue clay (bedrock).	149-201 feet: white, blue, gray clay (rock).	133-146 feet: mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		Bk-683	Bk-729	Bk-731	Bk-732
Well number		Bk-683	Bk-729	Bk-731	Bk-732
Source of log		U.S. Steel Co.	U.S. Steel Co.	Pa. Railroad	Pa. Railroad
Altitude (msl)		14 feet	12 feet	8 feet	8 feet
Total depth (feet)		155	96	181	100
Recent (undifferentiated)		0-12 feet: clay and boulders.	0-6 feet: sandy loam.		0-4 feet: sandy loam.
Pleistocene (undifferentiated)		12-52 feet: brown sand, gravel and boulders.	6-34 feet: sand and gravel.	0-46 feet: sand and gravel.	4-30 feet: coarse gravel.
Raritan formation	Upper clay member		34-38 feet: clay.	46-163 feet[4].	
	Old Bridge sand member	52-72 feet: fine brown and yellow sand.	38-63 feet: gray sand.		30-64 feet: sand.
	Middle clay member	72-120 feet: red, yellow, gray, white clay and brown sand.	63-96 feet: red, white, gray and brownish red clay.		64-100 feet: clay.
	Sayreville sand member				
	Lower clay member				
	Farrington sand member				
Crystalline rocks		120-155 feet: mica rock.		163-181 feet: mica schist.	

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Well number		Bk-733
Source of log		U.S. Steel Co.
Altitude (msl)		14 feet
Total depth (feet)		102
Recent (undifferentiated)		0-7 feet: sandy loam.
Pleistocene (undifferentiated)		7-35 feet: brown sand and gravel.
Raritan formation	Upper clay member	
	Old Bridge sand member	35-53 feet: fine gray sand.
	Middle clay member	53-59 feet: red and gray clay.
	Sayreville sand member	59-102 feet: yellow, brown and gray sand.
	Lower clay member	
	Farrington sand member	
Crystalline rocks		

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-1	B-2	B-3	B-4
Boring number		B-1	B-2	B-3	B-4
Source of log		Vehicular Tunnel Penrose Ave. at Schuylkill River	Vehicular Tunnel Penrose Ave. at Schuylkill River	Vehicular Tunnel Penrose Ave. at Schuylkill River	Vehicular Tunnel Penrose Ave. at Schuylkill River
Altitude (msl)		5 feet	7 feet	8 feet	10 feet
Total depth (feet)		97	72	73	103
Recent (undifferentiated)		0-22 feet: mud.	0-36 feet: mud.	0-38 feet: mud	0--40 feet: mud.
Pleistocene (undifferentiated)		22-46 feet: sand and gravel.	36-54 feet: medium sand.	38-58 feet: medium sand.	40-65 feet: sand and gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member	46-50 feet[2]: red clay.	54-58 feet[2]: red clay.		
	Sayreville sand member				
	Lower clay member				
	Farrington sand member	50-87 feet: fine sand and yellow clay.	58-72 feet: fine to medium sand.	58-73 feet: fine sand and gravel.	65-93 feet: fine sand.
Crystalline rocks		87-97 feet: yellow clay, mica and rock.			93-103 feet: fine sand, mica and rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

	Boring number	B-5	B-6	B-7	B-8
	Source of log	Vehicular Tunnel Penrose Ave. at Schuylkill River	Vehicular Tunnel Penrose Ave. at Schuylkill River	Vehicular Tunnel Penrose Ave. at Schuylkill River	Vehicular Tunnel Penrose Ave. at Schuylkill River
	Altitude (msl)	4 feet	4 feet	0 feet	0 feet
	Total depth (feet)	85	91	87	97
	Recent (undifferentiated)	0-29 feet: fill and mud.	0-32 feet: fill and mud.	0-14 feet: river and river mud.	0-20 feet: river and river mud.
	Pleistocene (undifferentiated)	29-50 feet: fine sand and gravel.	32-52 feet: sand and coarse gravel.	14-50 feet: sand and gravel.	20-36 feet: sand and gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member	50-54 feet[2]: red clay.	52-54 feet[2]: red clay.	50-60 feet[2]: red clay.	36-40 feet[2]: white clay.
	Sayreville sand member				
	Lower clay member				
	Farrington sand member	54-85 feet: fine sand.	54-91 feet: fine sand.	60-83 feet: fine and coarse sand.	40-92 feet: fine sand and gravel.
	Crystalline rocks	85 feet: white clay and sand.		83-87 feet: fine sand (residual bedrock).	92-97 feet: rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Boring number	B-9	B-10	B-11	B-12
Source of log	Vehicular Tunnel Penrose Ave. at Schuylkill River	Vehicular Tunnel Penrose Ave. at Schuylkill River	Vehicular Tunnel Penrose Ave. at Schuylkill River	Vehicular Tunnel Penrose Ave. at Schuylkill River
Altitude (msl)	0 feet	0 feet	0 feet	3 feet
Total depth (feet)	99	101	103	134
Recent (undifferentiated)	0-36 feet: river and river mud.	0-42 feet: river and river mud.	0-36 feet: river and river mud.	0-72 feet: fill and river mud.
Pleistocene (undifferentiated)			36-56 feet: sand and gravel.	
Raritan formation: Upper clay member				
Raritan formation: Old Bridge sand member				
Raritan formation: Middle clay member	36-44 feet[2]: red clay.	42-50 feet[2]: red clay.		
Raritan formation: Sayreville sand member				
Raritan formation: Lower clay member				
Raritan formation: Farrington sand member	44-99 feet: fine sand and gravel.	50-101 feet: fine sand and coarse gravel.	56-83 feet: fine and coarse sand.	72-115 feet: medium and fine sand, some gravel.
Crystalline rocks			83-103 feet: mica sand and rock.	115-134 feet: mica and rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-13	B-14	B-15	B-16
Boring number		B-13	B-14	B-15	B-16
Source of log		Vehicular Tunnel Penrose Ave. at Schuylkill River	Vehicular Tunnel Penrose Ave. at Schuylkill River	Schuylkill Pumping Station	Central Schuylkill Pumping Station
Altitude (msl)		3 feet	1 foot	7 feet	0 feet
Total depth (feet)		101	124	57	50
Recent (undifferentiated)		0-59 feet: fill and river mud.	0-49 feet: fill and river mud.	0-44 feet: sand and gravel and brown sandy clay.	0-13 feet: river mud.
Pleistocene (undifferentiated)		59-65 feet: sand and gravel.	49-69 feet: coarse sand.		13-46 feet: sand and gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member				
	Sayreville sand member				
	Lower clay member				
	Farrington sand member	65-88 feet: fine to coarse sand.	69-105 feet: fine sand.		
Crystalline rocks		88-101 feet: mica, sand and rock.	105-124 feet: mica, sand and rock.	44-57 feet: mica schist.	46-50 feet: rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

	Boring number	B-17	B-19	B-20	B-21
	Source of log	Market at elevated railroad	U. S. Housing	Central Schuylkill Pumping Station	Central Schuylkill Pumping Station
	Altitude (msl)	34 feet	18 feet	17 feet	17 feet
	Total depth (feet)	51	142	66	68
	Recent (undifferentiated)	0-17 feet: sand and soft clay.	0-10 feet: topsoil.	0-48 feet: fill and river mud	0-58 feet: fill and river mud and sand.
	Pleistocene (undifferentiated)	17-41 feet: clayey gravel.	10-58 feet: coarse sand and gravel.	48-62 feet: clay, sand, and gravel.	
Raritan formation	Upper clay member				
Raritan formation	Old Bridge sand member				
Raritan formation	Middle clay member		58-108 feet[2]: clay.		
Raritan formation	Sayreville sand member				
Raritan formation	Lower clay member				
Raritan formation	Farrington sand member		108-128 feet: coarse sand and gravel.		
	Crystalline rocks	41-51 feet: black clay and mica rock.	128-142 feet: clay and rock.	62-66 feet: mica schist	58-68 feet: mica clay, sand, and soft mica schist.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-22	B-23	B-24	B-27
Boring number		B-22	B-23	B-24	B-27
Source of log		Central Schuylkill Pumping Station	Central Schuylkill Pumping Station	Central Schuylkill Pumping Station	Central Schuylkill Pumping Station
Altitude (msl)		0 feet	0 feet	7 feet	9 feet
Total depth (feet)		51	60	47	52
Recent (undifferentiated)		0-35 feet: river and river mud.	0-36 feet: river and river mud and boulders.	0-21 feet: fill and river mud.	0-17 feet: fill
Pleistocene (undifferentiated)		35-46 feet: sand.	36-55 feet: sand and gravel.	21-27 feet: sand clay, and gravel.	17-32 feet: clay, sand, and gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member				32-38 feet[2]: brown clay.
	Sayreville sand member				
	Lower clay member				
	Farrington sand member			27-41 feet: sand and gravel.	38-52 feet: clay, sand, and gravel.
Crystalline rocks		46-51 feet: mica rock.	55-60 feet: mica rock.	41-47 feet: mica schist.	

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Boring number	B-45	B-48	B-49	B-51
Source of log	31st & Chestnut	Pa. Terminal, West of Schuylkill River	Pa. Terminal, West River Drive	Corner of 23rd and Chesnut
Altitude (msl)	25 feet	2 feet	5 feet	22 feet
Total depth (feet)	22	51	56	19
Recent (undifferentiated)	0-19 feet: fill, sand, and clay.	0-35 feet: fill and river mud.	0-43 feet: river mud.	0-15 feet: fill and clay.
Pleistocene (undifferentiated)		35-50 feet: gravel.	43-55 feet: gravel.	15-17 feet: sand and gravel.
Raritan formation: Upper clay member				
Raritan formation: Old Bridge sand member				
Raritan formation: Middle clay member				
Raritan formation: Sayreville sand member				
Raritan formation: Lower clay member				
Raritan formation: Farrington sand member				
Crystalline rocks	19-22 feet: mica rock.	50-51 feet: rock.	55-56 feet: rock.	17-19 feet: rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Boring number		B-52	B-53	B-55	B-56
Source of log		Pa. Terminal, West River Drive		Pa. Terminal, West of Schuylkill River	Pa. Terminal, West of Schuylkill River
Altitude (msl)		5 feet	20 feet	4 feet	6 feet
Total depth (feet)		54	18	56	64
Recent (undifferentiated)		0-43: feet: fill and river mud.	0-18 feet: fill and clay.	0-37 feet: fill and mud.	0-25 feet: fill and mud.
Pleistocene (undifferentiated)		43-53 feet: gravel.		37-55 feet: gravel, sand, and mud.	25-63 feet: gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member				
	Sayreville sand member				
	Lower clay member				
	Farrington sand member				
Crystalline rocks		53-54 feet: rock.	18 feet: rock.	55-56 feet: rock.	63-64 feet: rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Boring number	B-57	B-59	B-60	B-70
Source of log	Pa. Terminal, west of Schuylkill River	Pa. Terminal, west of Schuylkill River	Pa. Terminal, west of Schuylkill River	Market Street, Elevated Railroad Co.
Altitude (msl)	0 feet	10 feet	10 feet	36 feet
Total depth (feet)	53	77	59	46
Recent (undifferentiated)	0-35 feet: fill and river mud.	0-69 feet: fill and mud and clay.	0-47 feet: fill and river mud.	0-21 feet; clay and sandy loam.
Pleistocene (undifferentiated)	35-52 feet: sand and gravel.		47-53 feet: sand and gravel.	21-43 feet: clayey gravel.
Raritan formation: Upper clay member				
Raritan formation: Old Bridge sand member				
Raritan formation: Middle clay member				
Raritan formation: Sayreville sand member				
Raritan formation: Lower clay member				
Raritan formation: Farrington sand member				
Crystalline rocks	52-53 feet: rock.	69-77 feet: mica rock.	53-59 feet: mica rock.	43-46 feet: mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-71	B-72	B-73	B-74
Boring number		B-71	B-72	B-73	B-74
Source of log		Market Street Elevated Railroad Co.	Market Street, Elevated Railroad Co.	Market Street, Elevated Railroad Co.	Market Street Elevated Railroad Co.
Altitude (msl)		3 feet	33 feet	31 feet	27 feet
Total depth (feet)		51	46	68	51
Recent (undifferentiated)		0-37 feet: mud.	0-19 feet: sand and clay.	0-14 feet: sand and clayey loam.	0-17 feet: clay and sandy loam.
Pleistocene (undifferentiated)		37-50 feet: gravel.	19-31 feet: coarse gravel.	14-46 feet: coarse gravel, little clay.	17-39 feet: coarse gravel, little clay.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member		31-32 feet[2]: stiff clay.	46-54 feet[2]: stiff clay.	39-44 feet[2]: clay and sand.
	Sayreville sand member				
	Lower clay member				
	Farrington sand member		32-37 feet: gravel and clay.	54-64 feet: sand and gravel, some white and clean.	44-51 feet: sand, gravel, and clay.
Crystalline rocks		50-51 feet: rock.	37-46 feet: clay and rock.	64-68 feet: rock.	

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Boring number		B-76	B-77	B-78	B-79
Source of log		Market Street Elevated Railroad Co.	Market Street Elevated Railroad Co.	Market Street Elevated Railroad Co.	Market Street Elevated Railroad Co.
Altitude (msl)		21 feet	18 feet	20 feet	26 feet
Total depth (feet)		71	72	50	52
Recent (undifferentiated)		0-12 feet: sandy loam and clay.	0-16 feet: sandy loam and clay.	0-14 feet: sand, loam, and clay.	0-16 feet: sandy loam.
Pleistocene (undifferentiated)		12-36 feet: clayey and sharp gravel and sand.	16-36 feet: clayey and sharp gravel.	14-39 feet: clayey gravel and red gravel.	16-51 feet: clayey and sharp gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member			39-42 feet[2]: clay.	
	Sayreville sand member				
	Lower clay member				
	Farrington sand member	36-69 feet: sand, little gravel, and little clay.	36-68 feet: sand, gravel, and clay.	42-50 feet:gravel and some sand.	51-52 feet: sand.
Crystalline rocks		69-71 feet: mica rock.	68-72 feet: clay and mica rock.		

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Boring number		B-80	B-81	B-82	B-83
Source of log		Market Street Elevated Railroad Co.	Delaware R. Bridge Joint Commission	Delaware R. Bridge Joint Commission	Delaware R. Bridge Joint Commission
Altitude (msl)		22 feet	36 feet	33 feet	33 feet
Total depth (feet)		51	82	84	86
Recent (undifferentiated)		0-13 feet: sandy loam.	0-15 feet: fill, sand, and mud.	0-13 feet: fill, yellow clay, and sand.	0-15 feet: fill, yellow sand, and clay.
Pleistocene (undifferentiated)		13-50 feet: clayey gravel and sand.	15-52 feet: sand and gravel.	13-48 feet: yellow and brown sand and gravel.	15-55 feet: sand and gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member				55-61 feet[2]: blue gray clay.
	Sayreville sand member				
	Lower clay member				
	Farrington sand member	50-51 feet: sand.	52-68 feet: clay, sand, and gravel.	48-64 feet: yellow sand, blue clay, and gravel.	61-84 feet: sand, and coarse gravel.
Crystalline rocks			68-82 feet: rock.	64-84 feet: mica rock.	84-86 feet: mica rock.

See footnotes at end of table.

in the Coastal Plain area of southeastern Pennsylvania—Continued

Boring number		B-84	B-85	B-86	B-87
Source of log		Delaware R. Bridge Joint Commission	Delaware R. Bridge Joint Commission	Delaware R. Bridge Joint Commission	Delaware R. Bridge Joint Commission
Altitude (msl)		31 feet	8 feet	0 feet	8 feet
Total depth (feet)		90	72	63	100
Recent (undifferentiated)		0-24 feet: fill, yellow clay, and sand.		0-45 feet: river and river mud.	0-20 feet: fill and river silt.
Pleistocene (undifferentiated)		24-48 feet: fine sand and coarse gravel.	0-23 feet: sand:		20-38 feet: fine to coarse brown sand and gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				38-71 feet: brown to gray sand and some clay and gravel.
	Middle clay member	48-58 feet[2]: brown sandy clay.	23-33 feet[2]: clay and sand.		71-100 feet[2]: red and white clay with some fine sand.
	Sayreville sand member				
	Lower clay member				
	Farrington sand member	58-84 feet: sand and gravel and mica.	33-70 feet: sand.	45-63 feet: sand.	
Crystalline rocks		84-90 feet: mica rock.	70-72 feet: mica rock.	63 feet: rock.	

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Boring number		B-88	B-89	B-90	B-92
Source of log		Delaware R. Bridge Joint Commission	Delaware R. Bridge Joint Commission	Delaware R. Bridge Joint Commission	Phila. Electric Co.
Altitude (msl)		11 feet	10 feet	9 feet	7 feet
Total depth (feet)		120	205	200	125
Recent (undifferentiated)		0-48 feet: fill, sand and bluish silt.	0-40 feet: fill and river silt.	0-26 feet: cinder fill and gray river silt and sand.	0-38 feet: fill and river silt.
Pleistocene (undifferentiated)		48-53 feet: gray sand.		26-35 feet: coarse sand and gravel and gray silt.	38-55 feet: sand and coarse gravel.
Raritan formation	Upper clay member	53-63 feet: gray silt.	40-45 feet: dark gray silt	35-45 feet: gray fine silt and sand and gravel.	
	Old Bridge sand member	63-86 feet: silt, coarse sand and gravel.	45-100 feet: sand and gravel.	45-86 feet: gray and white sand and gravel and clay.	55-92 feet: fine to coarse sand, fine gravel and white clay.
	Middle clay member	86-120 feet[2]: gray and red clay.	100-134 feet: red and gray clay, some sand.	86-136 feet: red and gray clay.	92-125 feet: red, pink, gray, and white clay.
	Sayreville sand member		134-155 feet: fine brown and white sand	136-148 feet: light gray sand.	
	Lower clay member		155-172 feet: gray clay and some sand and pea gravel.	148-175 feet: gray clay and sand and coarse gravel.	
	Farrington sand member		172-198 feet: gray sand and large gravel.	175-193 feet: sand and gravel and whitish gray clay.	
Crystalline rocks			198-205 feet: gray micaceous clay.	193-200 feet: compact gray and brown clay.	

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-93	B-95	B-97	B-98
Boring number		B-93	B-95	B-97	B-98
Source of log		Phila. Electric Co.	Pa. Railroad Co.	Tacony Bridge	Tacony Bridge
Altitude (msl)		7 feet	0 feet	4 feet	5 feet
Total depth (feet)		201	110	40	42
Recent (undifferentiated)		0-38 feet: fill and river silt.	0-12 feet: sand, clay, and mud.	0-10 feet: cinders.	0-6 feet: loam.
Pleistocene (undifferentiated)		38-60 feet: sand and coarse gravel.	12-23 feet: sand and gravel.	10-18 feet: gravel.	6-40 feet: sand, gravel, and clay.
Raritan formation	Upper clay member		23-26 feet: clay.		
	Old Bridge sand member	60-92 feet: sand, fine gravel, and clay.	26-51 feet: sand.		
	Middle clay member	92-158 feet[2]: pink, white, and gray clay.	51-54 feet[2]: clay.	18-21 feet[2]: clay.	
	Sayreville sand member				
	Lower clay member				
	Farrington sand member	158-201 feet: sand and fine gravel.	54-87 feet: sand and gravel.	21-38 feet: sand.	
Crystalline rocks			87-110 feet: rock.	38-40 feet: gneiss.	40-42 feet: gneiss.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-99	B-100	B-101	B-102
Boring number		B-99	B-100	B-101	B-102
Source of log		Tacony Bridge	Tacony Bridge	Tacony Bridge	Tacony Bridge
Altitude (msl)		0 feet	0 feet	0 feet	0 feet
Total depth (feet)		68	60	70	87
Recent (undifferentiated)		0-6 feet: loam.	0-41 feet: river and sand and gravel.	0-45 feet: river and river mud.	0-55 feet: sandy mud.
Pleistocene (undifferentiated)		6-37 feet: sand and gravel.		45-57 feet: sand and gravel.	55-57 feet: gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member				
	Sayreville sand member				
	Lower clay member				
	Farrington sand member				
Crystalline rocks		37-68 feet: gneiss.	41-60 feet: gneiss.	57-70 feet: gneiss.	57-87 feet: gneiss.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Boring number	B-103	B-106	B-107	B-108
Source of log	Tacony Bridge	Phila. Gas Co.	Phila. Gas Co.	Phila. Gas Co.
Altitude (msl)	0 feet	28 feet	0 feet	0 feet
Total depth (feet)	75	110	82	119
Recent (undifferentiated)	0-59 feet: sandy mud.	0-12 feet: cinders and clay fill.	0-44 feet: river and river silt.	0-46 feet: river and river silt.
Pleistocene (undifferentiated)	59-62 feet: gravel.	12-43 feet: sand and some gravel.	44-55 feet: sand and gravel.	46-62 feet: sand.
Raritan formation: Upper clay member				
Raritan formation: Old Bridge sand member				
Raritan formation: Middle clay member		43-66 feet[2]: red clay.	55-64 feet[2]: clay	
Raritan formation: Sayreville sand member				
Raritan formation: Lower clay member				
Raritan formation: Farrington sand member		66-96 feet: sand and little gravel and clay.	64-69 feet: sand and gravel.	
Crystalline rocks	62-75 feet: gneiss.	96-110 feet: mica rock.	69-82 feet: mica rock.	62-119 feet: clay, and mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Boring number		B-109	B-117	B-118	B-119
Source of log		Phila. Gas Co.	Pa. Terminal, west of Schuylkill River	Pa. Terminal, east of Schuylkill River	Phila. Rapid Transit Co.
Altitude (msl)		0 feet	3 feet	0 feet	20 feet
Total depth (feet)		82	46	32	28
Recent (undifferentiated)		0-43 feet: river and river silt.	0-38 feet: fill and mud.	0-21 feet: river and river mud.	0-18 feet: clay, sandy loam, and coarse gravel.
Pleistocene (undifferentiated)		43-61 feet: sand.	38-45 feet: gravel.	21-32 feet: gravel.	18-24 feet: coarse gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member				
	Sayreville sand member				
	Lower clay member				
	Farrington sand member				
Crystalline rocks		61-82 feet: clay and mica rock.	45-46 feet: rock.	32 feet: rock.	24-28 feet: mica rock.

See footnotes at end of table.

Table 11.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Boring number		B-121	B-123	B-124	B-125
Source of log		Phila. Rapid Transit Co.	Delaware R. Bridge Joint Commission	U.S. Army Engrs.	U.S. Army Engrs.
Altitude (msl)		35 feet	10 feet	0 feet	0 feet
Total depth (feet)		38	102	50	50
Recent (undifferentiated)		0-9 feet: clay.	0-44 feet: cinders and gray silt.	0-34 feet: river and silt, sand and gravel.	0-32 feet: river, river mud, sand and gravel.
Pleistocene (undifferentiated)		9-35 feet: sand and gravel.			
Raritan formation	Upper clay member				
	Old Bridge sand member		44-67 feet: gray sand and silt.		
	Middle clay member		67-81 feet: gray clay and silt.		
	Sayreville sand member		81-96 feet: brown sand and fine gravel.		
	Lower clay member		96-102 feet: red clay.		
	Farrington sand member				
Crystalline rocks		35-38 feet: mica rock.		34-50 feet: rock:	32-50 feet: schist.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-126	B-127	B-128	B-129
Boring number		B-126	B-127	B-128	B-129
Source of log		U.S. Army Engrs.	U.S. Army Engrs.	U.S. Army Engrs.	U.S. Army Engrs.
Altitude (msl)		0 feet	0 feet	0 feet	0 feet
Total depth (feet)		50	50	50	50
Recent (undifferentiated)		0-33 feet: river and silt, sand and gravel.	0-36 feet: river, mud, sand and gravel.	0-35 feet: river, sand, and gravel.	0-35 feet: river and sand and gravel.
Pleistocene (undifferentiated)					
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member				
	Sayreville sand member				
	Lower clay member				
	Farrington sand member				
Crystalline rocks		33-50 feet: mica rock.	36-50 feet: mica rock.	35-50 feet: mica rock.	35-50 feet: mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-130	B-131	B-132	B-133
Boring number		B-130	B-131	B-132	B-133
Source of log		U.S. Army Engrs.	U.S. Army Engrs.	Warner Co.	Pa. Turnpike Comm.
Altitude (msl)		0 feet	0 feet	0 feet	31 feet
Total depth (feet)		50	50	49	68
Recent (undifferentiated)		0-29 feet: river, and mud and sand.	0-13 feet: river	0-5 feet: clay.	0-2 feet: soil.
Pleistocene (undifferentiated)			13-32 feet: sand and gravel.	5-46 feet: sand and gravel.	2-42 feet: sand and gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member		32-50 feet: brown, red and white clay and fine sand.		
	Middle clay member				
	Sayreville sand member				
	Lower clay member				
	Farrington sand member				
Crystalline rocks		29-50 feet: mica rock.		46-49 feet: residual clay.	42-68 feet: schist.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-134	B-135	B-136	B-137
Boring number		B-134	B-135	B-136	B-137
Source of log		Pa. Turnpike Comm.	Pa. Turnpike Comm.	Pa. Turnpike Comm.	Pa. Turnpike Comm.
Altitude (msl)		32 feet	29 feet	27 feet	27 feet
Total depth (feet)		66	76	114	95
Recent (undifferentiated)		0-2 feet: soil.	0-2 feet: soil.	0-2 feet: soil.	0-2 feet: soil.
Pleistocene (undifferentiated)		2-41 feet: sand and gravel.	2-53 feet: sand and gravel.	2-52 feet: sand and gravel.	2-42 feet: sand and gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member				
	Sayreville sand member				
	Lower clay member				
	Farrington sand member				
Crystalline rocks		41-66 feet: schist.	53-76 feet: schist.	52-114 feet: schist.	42-95 feet: schist.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Boring number		B-138	B-139	B-140	B-141
Source of log		Pa. Turnpike Comm.	Pa. Turnpike Comm.	Pa. Turnpike Comm.	Pa. Turnpike Comm.
Altitude (msl)		22 feet	28 feet	30 feet	28 feet
Total depth (feet)		170	67	89	107
Recent (undifferentiated)		0-2 feet: soil.	0-2 feet: soil.	0-2 feet: soil.	0-2 feet: soil.
Pleistocene (undifferentiated)		2-30 feet: sand and gravel.	2-32 feet: sand and gravel.	2-31 feet: sand and gravel.	2-32 feet: sand and gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member		32-55 feet: brown sand.	31-54 feet: brown sand with basal boulder gravel.	32-51 feet: brown sand with basal boulder gravel.
	Middle clay member				
	Sayreville sand member				51-56 feet: light brown, fine to coarse sand and gravel.
	Lower clay member				
	Farrington sand member				
Crystalline rocks		30-170 feet: schist.	55-67 feet: schist.	54-89 feet: schist.	56-107 feet: schist.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

	Boring number	B-142	B-143	B-144	B-145
	Source of log	Pa. Turnpike Comm.	Pa. Turnpike Comm.	Pa. Turnpike Comm.	Pa. Turnpike Comm.
	Altitude (msl)	23 feet	14 feet	20 feet	16 feet
	Total depth (feet)	188	174	165	86
	Recent (undifferentiated)	0-2 feet: soil.	0-2 feet: soil.	0-2 feet: soil.	0-2 feet: soil
	Pleistocene (undifferentiated)	2-10 feet: sand and gravel.	2-14 feet: sand and gravel.	2-18 feet: sand and gravel.	2-22 feet: sand and gravel.
Raritan formation	Upper clay member	10-20 feet: brown clayey silt.			
	Old Bridge sand member	20-42 feet: brown sand with basal boulder gravel.	14-38 feet: brown sand with basal boulder gravel.	18-35 feet: brown sand and gravel.	22-38 feet: brown. sand and gravel.
	Middle clay member				
	Sayreville sand member	42-51 feet: light brown, fine to coarse sand and gravel		35-57 feet: medium to fine sand and clay layers.	38-69 feet: medium to fine sand and clay layers.
	Lower clay member				
	Farrington sand member				
	Crystalline rocks	51-96 feet: schist.	38-174 feet: schist.	57-165 feet: schist.	69-86 feet: schist.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-146	B-147	B-148	B-149
Boring number		B-146	B-147	B-148	B-149
Source of log		Pa. Turnpike Comm.	Pa. Turnpike Comm.	Pa. Turnpike Comm.	Pa. Turnpike Comm.
Altitude (msl)		9 feet	0 feet	0 feet	8 feet
Total depth (feet)		129	153	158	84
Recent (undifferentiated)		0-10 feet: clayey silt and fine sand.	0-19 feet: river water.	0-24 feet: river water and fine clayey sand.	0-12 feet: river silts and sand and gravel.
Pleistocene (undifferentiated)		10-36 feet: sand and gravel.	19-30 feet: sand and gravel.	24-32 feet: sand and gravel.	12-35 feet: sand and gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member		30-36 feet: brown fine sandy silt.		
	Middle clay member		36-41 feet: red and gray clay.	32-36 feet: red and gray clay.	35-50 feet: red and gray clay.
	Sayreville sand member		41-42 feet: brown, fine to coarse sand.	36-48 feet: brown, fine to coarse sand.	50-58 feet: brown, fine to coarse sand.
	Lower clay member				
	Farrington sand member				
Crystalline rocks		36-129 feet: schist.	42-153 feet: schist.	48-158 feet: schist.	58-84 feet: schist.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-150	B-151	B-152	B-153
Source of log		Pa. Turnpike Comm.	Pa. Turnpike Comm.	Pa. Turnpike Comm.	Pa. Turnpike Comm.
Altitude (msl)		13 feet	15 feet	17 feet	17 feet
Total depth (feet)		157	114	170	150
Recent (undifferentiated)		0-2 feet: soil.	0-2 feet: soil.	0-2 feet: soil.	0-2 feet: soil.
Pleistocene (undifferentiated)		2-26 feet: sand and gravel.	2-38 feet: sand and gravel.	2-19 feet: sand and gravel.	2-19 feet: sand and gravel.
Raritan formation	Upper clay member		38-46 feet: brown and gray clayey silt.	19-39 feet: red and gray clay and brown and gray clayey silt.	
	Old Bridge sand member	26-43 feet: brown to gray, fine to medium sand.	46-52 feet: brown to gray, fine to medium sand.	39-50 feet: brown to gray, fine to medium sand.	19-30 feet: brown fine to coarse sand.
	Middle clay member	43-81 feet: red and gray clay and sand stringer.	52-79 feet: red and gray clay.	50-74 feet: red and gray clay.	30-80 feet: red and gray clay.
	Sayreville sand member	81-86 feet: brown fine to coarse sand.	79-90 feet: brown fine to coarse sand.	74-108 feet: brown fine to coarse sand.	80-103 feet: brown fine to coarse sand.
	Lower clay member				
	Farrington sand member				
Crystalline rocks		86-157 feet: schist.	90-114 feet: schist.	108-170 feet: schist.	103-150 feet: schist.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-154	B-155	B-156	B-157
Boring number		B-154	B-155	B-156	B-157
Source of log		Pa. Turnpike Comm.	Pa. Turnpike Comm.	Pa. Turnpike Comm.	Pa. Turnpike Comm.
Altitude (msl)		21 feet	31 feet	28 feet	25 feet
Total depth (feet)		121	115	223	163
Recent (undifferentiated)		0-2 feet: soil.	0-2 feet: soil.	0-2 feet: soil.	0-2 feet: soil.
Pleistocene (undifferentiated)		2-25 feet: sand and gravel.	2-28 feet: sand and gravel.	2-23 feet: sand and gravel.	2-28 feet: sand and gravel.
Raritan formation	Upper clay member				28-35 feet: gray and brown clay.
	Old Bridge sand member	25-34 feet: brown fine to coarse sand.	28-43 feet: brown fine to coarse sand.	23-59 feet: brown fine to coarse sand.	35-48 feet: brown fine to coarse sand and silty clay.
	Middle clay member	34-91 feet: red and gray clay.	43-60 feet: red and gray clay, silty sand and wood at base.	59-80 feet: red and gray clay, silty sand and wood at base.	48-82 feet: red and gray clay, silty sand and wood at base.
	Sayreville sand member		60-92 feet: brown fine to coarse sand.	80-110 feet: brown fine to coarse sand.	82-102 feet: brown fine to coarse sand.
	Lower clay member				
	Farrington sand member				
Crystalline rocks		91-121 feet: weathered mica schist.	92-115 feet: schist.	110-223 feet: schist.	102-163 feet: schist.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Boring number		B-158	B-159	B-160	B-161
Source of log		Pa. Turnpike Comm.	U.S. Army Engrs.	U.S. Army Engrs.	U.S. Army Engrs.
Altitude (msl)		24 feet	0 feet	0 feet	0 feet
Total depth (feet)		140	50	50	50
Recent (undifferentiated)		0-2 feet: soil.	0-25 feet: river.	0-16 feet: river.	0-20 feet: river.
Pleistocene (undifferentiated)		2-22 feet: sand and gravel.	25-30 feet: sand and gravel.	16-26 feet: sand and gravel.	20-30 feet: sand with gravel.
Raritan formation	Upper clay member	22-36 feet: gray and brown clay.			
	Old Bridge sand member	36-45 feet: brown fine to coarse sand.			
	Middle clay member	45-87 feet: red and gray clay and silty sand and wood near base.	30-34 feet: yellow, red, and white clay.	26-32 feet: clay.	30-33 feet: tan clay.
	Sayreville sand member	87-96 feet: brown fine to coarse sand.			
	Lower clay member				
	Farrington sand member				
Crystalline rocks		96-140 feet: schist.	34-50 feet: residual rock.	32-50 feet: disintegrated rock.	33-50 feet: weathered residual clay and mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-162	B-163	B-164	B-165
Boring number		B-162	B-163	B-164	B-165
Source of log		U.S. Army Engrs.	U.S. Army Engrs	Warner Co.	Warner Co.
Altitude (msl)		0 feet	0 feet	10 feet	14 feet
Total depth (feet)		50	50	36	52
Recent (undifferentiated)		0-25 feet: river.	0-23 feet: river.	0-9 feet: top-soil.	0-4 feet: soil.
Pleistocene (undifferentiated)		25-30 feet: sand and gravel.	23-29 feet: sand and gravel.	9-36 feet: sand and gravel.	4-52 feet: sand and gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member				
	Sayreville sand member				
	Lower clay member				
	Farrington sand member				
Crystalline rocks		30-50 feet: mica rock.	29-50 feet: mica rock.	36 feet: mica rock and clay.	52 feet: mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-166	B-167	B-168	B-172
Source of log		Warner Co.	Warner Co.	Warner Co.	Warner Co.
Altitude (msl)		22 feet	21 feet	25 feet	23 feet
Total depth (feet)		37	20	32	44
Recent (undifferentiated)		0-3 feet: top-soil.	0-5 feet: top-soil.	0-12 feet: top-soil and clay.	
Pleistocene (undifferentiated)		3-34 feet: sand and gravel.	5-18 feet: sand and pebbles.	12-30 feet: sand and pebbles.	0-32 feet: sand and gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member			30-32 feet: yellow clay.	
	Sayreville sand member				32-44 feet: fine sand.
	Lower clay member				
	Farrington sand member				
Crystalline rocks		34-37 feet: mica rock.	18-20 feet: clay.		44 feet: mica clay.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-173	B-189	B-193	B-194
Boring number		B-173	B-189	B-193	B-194
Source of log		Warner Co.	U.S.G.S. Boring	Warner Co.	Warner Co.
Altitude (msl)		25 feet	20 feet	42 feet	20 feet
Total depth (feet)		34	14	42	68
Recent (undifferentiated)		0-3 feet: top-soil.		0-3 feet: soil.	0-6 feet: topsoil.
Pleistocene (undifferentiated)		3-34 feet: sand and gravel.	0-12 feet: grayish brown gravel and sand.	3-41 feet: sand and gravel.	6-32 feet: sand and gravel.
Raritan formation	Upper clay member				32-68 feet[4].
	Old Bridge sand member				
	Middle clay member			41-42 feet: clay.	
	Sayreville sand member				
	Lower clay member				
	Farrington sand member				
Crystalline rocks			12-14 feet: bedrock.		

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-199	B-200	B-201	B-202
Source of log		Warner Co.	Warner Co.	Warner Co.	Warner Co.
Altitude (msl)		38 feet	35 feet	40 feet	42 feet
Total depth (feet)		35	40	43	41
Recent (undifferentiated)		0-12 feet: fine sand and mud.		0-8 feet: topsoil and some sand.	0-6 feet: white clay and pebbles.
Pleistocene (undifferentiated)		12-32 feet: sand and gravel.	0-16 feet: sand and gravel.	8-32 feet: sand and gravel.	6-30 feet: sand and pebbles.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member			32-36 feet: mud, fine sand, and pebbles.	
	Sayreville sand member		16-39 feet: sand and little gravel.	36-41 feet: fine sand.	30-41 feet: sand and few pebbles.
	Lower clay member				
	Farrington sand member				
Crystalline rocks		32-35 feet: rock.	39-40 feet: clay and mica.	41-43 feet: mica rock.	41 feet: rock.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-206	B-214	B-215	B-216
Source of log		Warner Co.	U.S. Steel Co.	U.S. Steel Co.	U.S. Steel Co.
Altitude (msl)		20 feet	19 feet	7 feet	10 feet
Total depth (feet)		96	76	69	80
Recent (undifferentiated)			0-9 feet: brown sandy clay and sand.	0-9 feet: sandy brown loam.	0-9 feet: sandy loam.
Pleistocene (undifferentiated)		0-28 feet: sand and gravel.	9-33 feet: sand and gravel.	9-26 feet: brown sand and gravel.	9-20 feet: gravel.
Raritan formation	Upper clay member		33-53 feet: white, gray, red, and brown sandy clay.	26-69 feet[1]: red and gray clay.	
	Old Bridge sand member		53-71 feet: white sand and clay.		20-43 feet: sand and clay.
	Middle clay member		71-95 feet: gray, white, and red clay.		43-80 feet: red and gray clay.
	Sayreville sand member				
	Lower clay member				
	Farrington sand member				
Crystalline rocks		28-96 feet: clay and mica rock.	95-194 feet: mica schist.	69 feet: mica rock.	

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Boring number	B-217	B-218	B-221	B-222
Source of log	U.S. Steel Co.	U.S. Steel Co.	U.S. Steel Co.	U.S. Steel Co.
Altitude (msl)	10 feet	17 feet	15 feet	10 feet
Total depth (feet)	70	92	90	190
Recent (undifferentiated)	0-8 feet: loam.	0-6 feet: brown sandy clay.	0-4 feet: sandy loam.	0-8 feet: sandy loam.
Pleistocene (undifferentiated)	8-28 feet: gravel.	6-19 feet: gravel.	4-21 feet: sand and gravel.	8-44 feet: sand and gravel.
Raritan formation: Upper clay member	28-70 feet[1]: yellow, gray, and red clay.		21-79 feet[4].	
Raritan formation: Old Bridge sand member		19-67 feet: white to brown sand.		44-65 feet: sand and gravel.
Raritan formation: Middle clay member		67-90 feet: red, yellow and red clay, and brown sand.		65-129 feet: clay and sand.
Raritan formation: Sayreville sand member				129-138 feet: sand and clay.
Raritan formation: Lower clay member				138-160 feet: clay.
Raritan formation: Farrington sand member				
Crystalline rocks		90-92 feet: mica rock.	79-90 feet: mica rock.	160-190 feet: mica rock.

in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-223	B-224	B-225	B-227
Boring number		B-223	B-224	B-225	B-227
Source of log		U.S. Steel Co.	U.S. Steel Co.	U.S. Steel Co.	U.S.G.S. Boring
Altitude (msl)		6 feet	5 feet	3 feet	18 feet
Total depth (feet)		113	95	93	54
Recent (undifferentiated)		0-7 feet: silty clay.	0-10 feet: sandy loam.	0-12 feet: gray clay and brown sand.	0-18 feet: silt and fine sand.
Pleistocene (undifferentiated)		7-25 feet: sand and gravel.	10-18 feet: gravel.	12-27 feet: sand and gravel.	18-29 feet: sand.
Raritan formation	Upper clay member	25-74 feet[4].			
	Old Bridge sand member		18-33 feet: medium coarse reddish brown sand.	27-45 feet: medium to coarse brown sand.	
	Middle clay member		33-69 feet: gray sandy clay.	45-80 feet: red and gray clay.	29-54 feet: red silt and clay.
	Sayreville sand member	74-113 feet: fine white sand.	69-73 feet: fine brownish sand.		
	Lower clay member				
	Farrington sand member				
Crystalline rocks		113 feet: rock.	73-95 feet: micaceous clay and mica rock.	80-93 feet: red clay with rock fragments.	

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

	Boring number	B-229	B-230	B-231	B-232
	Source of log	Warner Co.	Warner Co.	U.S. Steel Co.	U.S. Steel Co.
	Altitude (msl)	6 feet	39 feet	6 feet	8 feet
	Total depth (feet)	43	60	39	148
	Recent (undifferentiated)	0-13 feet: topsoil.	0-8 feet: topsoil and sandy yellow clay.		0-8 feet: topsoil, sand, and clay.
	Pleistocene (undifferentiated)	13-38 feet: sand and gravel.	8-26 feet: sand and gravel.	0-13 feet: brown sand and gravel.	8-38 feet: sand and gravel.
Raritan formation	Upper clay member		26-32 feet: sandy clay.		38-51 feet: yellow and gray clay.
Raritan formation	Old Bridge sand member		32-60 feet: sand and gravel.		51-68 feet: gray sand and clay.
Raritan formation	Middle clay member			13-36 feet: red and gray clay.	68-88 feet: gray and red clay.
Raritan formation	Sayreville sand member			36-39 feet: gray sand.	
Raritan formation	Lower clay member				
Raritan formation	Farrington sand member				
	Crystalline rocks	38-43 feet: mica rock.			88-148 feet: residual clay and mica rock.

See footnotes at end of table.

in the Coastal Plain area of southeastern Pennsylvania—Continued

	Boring number	B-233	B-234	B-235	B-246
	Source of log	U.S. Steel Co.	U.S. Steel Co.	U.S. Steel Co.	Warner Co.
	Altitude (msl)	12 feet	16 feet	13 feet	35 feet
	Total depth (feet)	49	100	102	50
	Recent (undifferentiated)	0-9 feet: brown sandy clay.	0-7 feet: brown clay loam.	0-12 feet: topsoil and sandy loam.	0-2 feet: topsoil.
	Pleistocene (undifferentiated)	9-13 feet: gravel.	7-27 feet: gravel with small boulders.	12-28 feet: gravel.	2-22 feet: sand and gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member		27-58 feet: white sand.	28-43 feet: coarse and fine sand.	22-48 feet: brown sand and little gravel.
	Middle clay member	13-49 feet: red and gray clay.	58-87 feet: dark gray clay.	43-77 feet: red and gray clay.	
	Sayreville sand member			77-102 feet: gray clayey sand.	
	Lower clay member				
	Farrington sand member				
	Crystalline rocks		87-100 feet: mica rock.		48-50 feet: mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Boring number		B-247	B-250	B-254	B-398
Source of log		Warner Co.	Warner Co.	U.S. Army Engrs.	Tacony Bridge
Altitude (msl)		21 feet	22 feet	0 feet	1 foot
Total depth (feet)		32	55	50	40
Recent (undifferentiated)		0-6 feet: topsoil.	0-3	0-33 feet: river and river mud.	0-4 feet: loam.
Pleistocene (undifferentiated)		6-16 feet: fine sand.	0-55 feet: sand and gravel.	33-43 feet: sand and gravel and white sand.	4-13 feet: gravel.
Raritan formation	Upper clay member			43-50 feet: white clay and sand.	
	Old Bridge sand member				
	Middle clay member				13-34 feet: clay.
	Sayreville sand member	16-32 feet: yellow coarse sand.			34-38 feet: gravel.
	Lower clay member				
	Farrington sand member				
Crystalline rocks			55 feet: mica clay.		38-40 feet: rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-399	B-400	B-401	B-403
Boring number		B-399	B-400	B-401	B-403
Source of log		Tacony Bridge	Delaware R. Bridge	Delaware R. Bridge	Delaware R. Bridge
Altitude (msl)		4 feet	0 feet	0 feet	4 feet
Total depth (feet)		42	73	82	100
Recent (undifferentiated)		0-7 feet: loam.	0-24 feet: river and mud and sand.	0-25 feet: river mud, and sand.	0-10 feet: fill, mud, and sand.
Pleistocene (undifferentiated)		7-15 feet: sand and gravel.	24-56 feet: sand and gravel.	25-53 feet: sand.	10-26 feet: sand, clay, and gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member	15-39 feet: clay.	56-66 feet[2]: clay.	53-75 feet[2]: clay.	26-40 feet: black clay.
	Sayreville sand member	39-40 feet: gravel.			40-62 feet: sand and gravel.
	Lower clay member				62-70 feet: blue clay.
	Farrington sand member		66-69 feet: sand and gravel.	75-82 feet: sand and gravel.	70-98 feet: sand and gravel.
Crystalline rocks		40-42 feet: rock.	69-73 feet: residual rock. Bedrock.	82 feet: bedrock.	98-100 feet: mica rock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

Boring number		B-404	B-406	B-407	B-408
Source of log		Delaware R. Bridge	Tacony Bridge	Tacony Bridge	Tacony Bridge
Altitude (msl)		6 feet	0 feet	0 feet	0 feet
Total depth (feet)		100	71	52	38
Recent (undifferentiated)		0-4 feet: fill.	0-39 feet: mud.	0-21 feet: mud.	0-21 feet: mud.
Pleistocene (undifferentiated)		4-29 feet: sand, gravel, and clay.	39-47 feet: gravel.	21-38 feet: gravel.	21-26 feet: gravel.
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member	29-44 feet: blue clay.			
	Sayreville sand member	44-64 feet: coarse sand.			
	Lower clay member	64-67 feet: blue clay.			
	Farrington sand member	67-94 feet: sand and gravel.			26-36 feet: sand:
Crystalline rocks		94-100 feet: mica rock.	47-71 feet: gneiss.	38-52 feet: gneiss.	36-38 feet: gneiss.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

		B-409	B-410	B-411	B-415
Boring number		B-409	B-410	B-411	B-415
Source of log		Phillips Tract	Phillips Tract	Phillips Tract	
Altitude (msl)		6 feet	7 feet	5 feet	4 feet
Total depth (feet)		140	136	142	160
Recent (undifferentiated)		0-45 feet: fill, mud, and clay	0-18 feet: fill and mud.	0-11 feet: fill and mud.	
Pleistocene (undifferentiated)			18-38 feet: sand and gravel.	11-36 feet: sand and gravel.	0-41 feet: gravel, sand, little clay.
Raritan formation	Upper clay member				41-51 feet: white clay.
	Old Bridge sand member		38-71 feet[2]: clay.		51-61 feet: coarse sand.
	Middle clay member	45-65 feet[2]: clay.		36-87 feet[2]: clay, little sand.	61-66 feet: white clay.
	Sayreville sand member				66-82 feet: coarse gravel.
	Lower clay member				82-97 feet: white clay.
	Farrington sand member	65-120 feet: sand and gravel.	71-121 feet: sand and gravel.	87-133 feet: sand and gravel.	97-143 feet: gravel, sand, little clay.
Crystalline rocks		120-140 feet: bedrock.	121-136 feet: residual clay, bedrock.	133-142 feet: residual clay, bedrock.	143-160 feet: bedrock.

See footnotes at end of table.

Table 14.—Interpretation of drillers' logs of wells and borings and well cutting samples in the Coastal Plain area of southeastern Pennsylvania—Continued

	Boring number	B-416	B-417
	Source of log	Delaware R. Bridge Joint Commission	Delaware R. Bridge Joint Commission
	Altitude (msl)	6 feet	6 feet
	Total depth (feet)	200	211
	Recent (undifferentiated)	0-32 feet: sand and fill.	0-28 feet: sand and gravel.
	Pleistocene (undifferentiated)	32-42 feet: sand and gravel.	28-39 feet: sand and gravel.
	Magothy formation	42-64 feet: sand, some gravel.	39-67 feet: sand, some gravel.
Raritan formation	Upper clay member		67-71 feet: yellow clay and sand.
	Old Bridge sand member	64-115 feet: sand, little clay, and gravel.	71-121 feet: sand, some gravel, and clay.
	Middle clay member	115-135 feet: gray, white, yellow and red clay.	121-138 feet: red and gray clay.
	Sayreville sand member	135-145 feet: sand.	138-149 feet: fine white sand.
	Lower clay member	145-148 feet: clay.	149-153 feet: red and gray clay.
	Farrington sand member	148-185 feet: white and yellow sand, some gravel.	153-190 feet: white and yellow sand, little clay.
	Crystalline rocks	185-200 feet: residual clay, bedrock.	190-211 feet: residual clay, mica rock.

1 Generalized Upper clay — Middle fire-clay section.
2 Combined Middle fire clay and Lower clay.
3 Combined thickness of Recent and Pleistocene.

Table 15—Interpretation of drillers' logs of wells in New Jersey adjacent to the Coastal Plain area of Southeastern Pennsylvania

Well number		J3	J4	J6	J7
Source of log		U.S.G.S. Ground Water Br. - N.J.	U.S.G.S. Ground Water Br. - N.J.	U.S.G.S. Ground Water Br. - N.J.	U.S.G.S. Ground Water Br. - N.J.
Altitude (msl)		10 feet	20 feet	10 feet	15 feet
Total depth (feet)		239	183	166	182
Recent (undifferentiated)		0-28 feet: fill and fine sand.			0-11 feet: sand and clay.
Pleistocene (undifferentiated)		28-55 feet: sand and gravel.	0-65 feet: sand and gravel.	0-20 feet: sand and gravel.	11-42 feet: gravel.
Magothy formation		55-58 feet: sand.			
Raritan formation	Upper clay member	58-65 feet: clay.	65-85 feet: clay and sand streaks.		42-50 feet: white clay.
	Old Bridge sand member	65-122 feet: sand, gravel, and little clay.	85-120 feet: medium coarse sand and clay streaks.	20-46 feet: white sand.	50-55 feet: white sand.
	Middle clay member	122-150 feet: clay.	120-131 feet: tough clay.	46-116 feet[1].	55-104 feet: red and white and gray clay.
	Sayreville sand member	150-173 feet: sand and gravel.	131-145 feet: coarse sand and fine gravel.		104-110 feet: sand.
	Lower clay member	173-189 feet: clay.	145-149 feet: tough clay.		110-123 feet: white clay.
	Farrington sand member	189-230 feet: sand.	149-166 feet: coarse sand and boulders.	116-162 feet: sand and gravel and little sandy clay.	123-182 feet: gravel and white clay stringer.
Crystalline rocks		230-239 feet: mica rock.	166-183 feet: mica rock.	162-166 feet: clay and rock.	182 feet: rock.

1 Generalized section.

Table 15—Interpretation of drillers' logs of wells in New Jersey adjacent to the Coastal Plain area of Southeastern Pennsylvania—Continued

		J8	J29	J30	J31
Well number		J8	J29	J30	J31
Source of log		U.S.G.S. Ground Water Br. - N.J.	U.S.G.S. Ground Water Br. - N.J.	U.S.G.S. Ground Water Br. - N.J.	U.S.G.S. Ground Water Br. - N.J.
Altitude (msl)		5 feet	15 feet	28 feet	30 feet
Total depth (feet)		160	132	175	164
Recent (undifferentiated)		0-7 feet: sandy clay.	0-6 feet: soil and clay.		
Pleistocene (undifferentiated)		7-55 feet: sand and gravel.	6-32 feet: gravel.	0-38 feet: sand.	0-31 feet: sand and gravel.
Magothy formation					
Raritan formation	Upper clay member				
	Old Bridge sand member				
	Middle clay member	55-80 feet: clay.	32-54 feet: red clay, sandy clay.	38-97 feet: red clay.	31-94 feet: clay, blue and white and red.
	Sayreville sand member	80-99 feet: sand and gravel.	54-76 feet: coarse gray sand.	97-115 feet: coarse sand.	94-117 feet: medium coarse sand.
	Lower clay member	99-103 feet: clay.	76-88 feet: blue clay.	115-147 feet: clay, fine sand and clay.	117-150 feet: clay, red and white.
	Farrington sand member	103-140 feet: sand and gravel.	88-108 feet: coarse gray sand.	147-171 feet: boulders.	
Crystalline rocks		140-160 feet: mica rock.	108-132 feet: clay and schist.	171-175 feet: bedrock.	150-164 feet: mica rock.

Coastal Plain area of Southeastern Pennsylvania—Continued

Well number		J32	J34	J42
Source of log		U.S.G.S. Ground Water Br. - N.J.	U.S.G.S. Ground Water Br. - N.J.	U.S.G.S. Ground Water Br. - N.J.
Altitude (msl)		25 feet	30 feet	5 feet
Total depth (feet)		170	142	279
Recent (undifferentiated)				0-13 feet: loam mud.
Pleistocene (undifferentiated)		0-32 feet: brown sand and gravel.	0-35 feet: sand. gravel, and boulders.	13-14 feet: coarse gravel.
Magothy formation				14-63 feet: white sand and clay, wood and gravel at base.
Raritan formation	Upper clay member			
	Old Bridge sand member			63-119 feet: fine white sand and clay and wood.
	Middle clay member	32-92 feet: red clay.	35-98 feet.	119-163 feet: red, yellow and blue clay.
	Sayreville sand member	92-115 feet: coarse sand.	98-135 feet: sand, medium gray, sand, coarse brown.	163-195 feet: sand and gravel and rotten wood.
	Lower clay member	115-143 feet: tough clay and sand.		195-201 feet: red and white clay.
	Farrington sand member	143-165 feet: boulders.		201-218 feet: sand, gravel, and thin beds of clay.
Crystalline rocks		165-170 feet: bedrock.	135-142 feet: residual clay, white.	218-279 feet: mica rock.

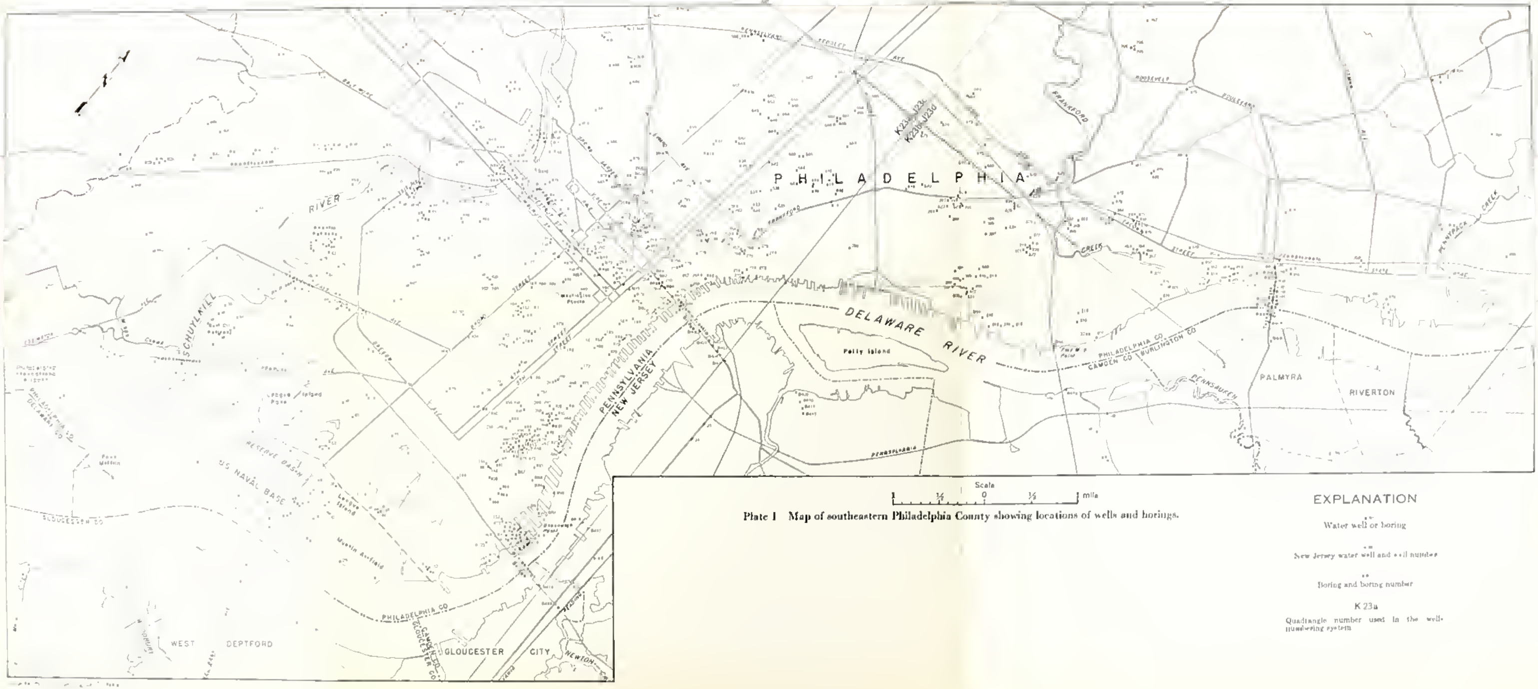


Plate 1 Map of southeastern Philadelphia County showing locations of wells and borings.

EXPLANATION

Water well or boring

New Jersey water well and well number

Boring and boring number

K 23a

Quadrangle number used in the well-numbering system

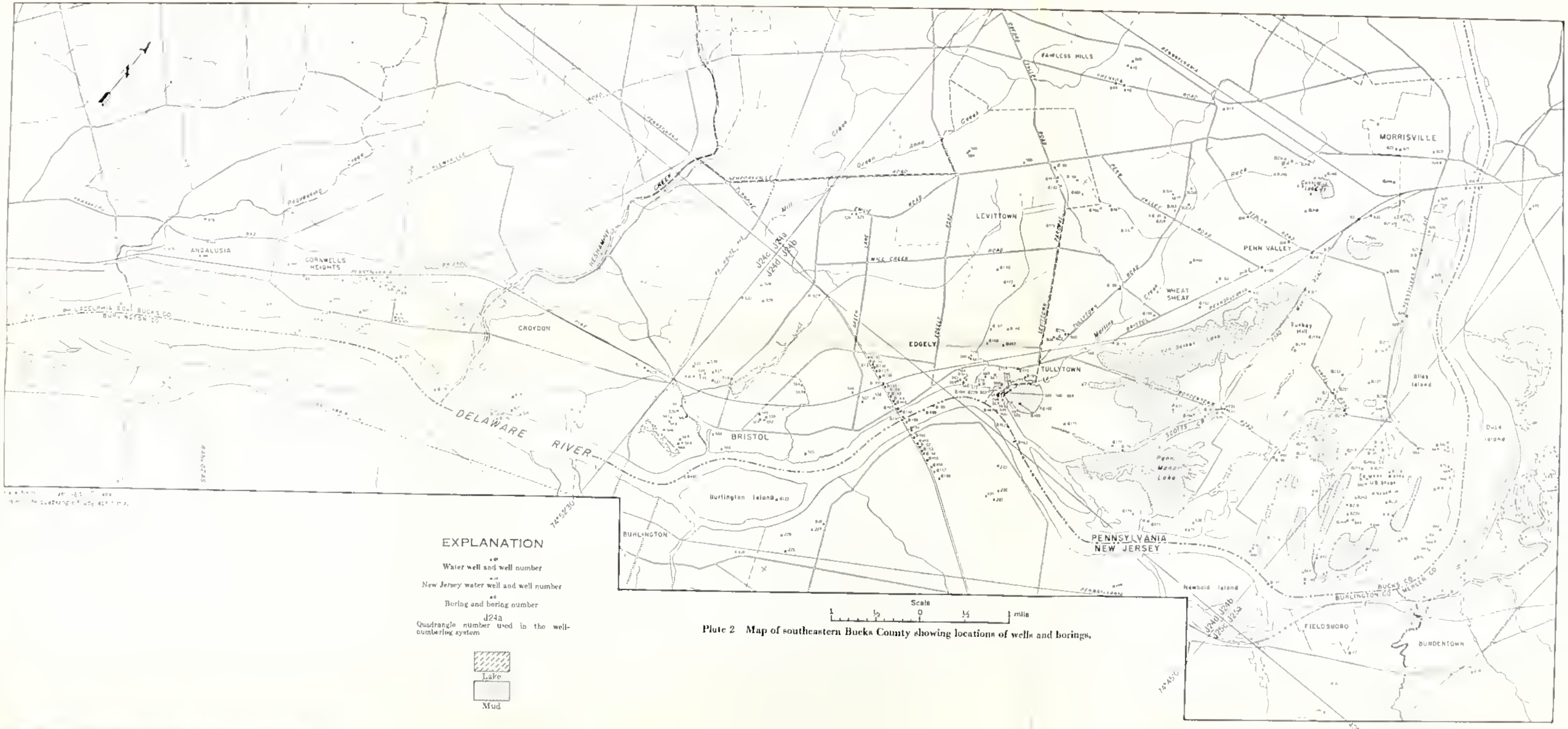


Plate 2 Map of southeastern Bucks County showing locations of wells and borings.

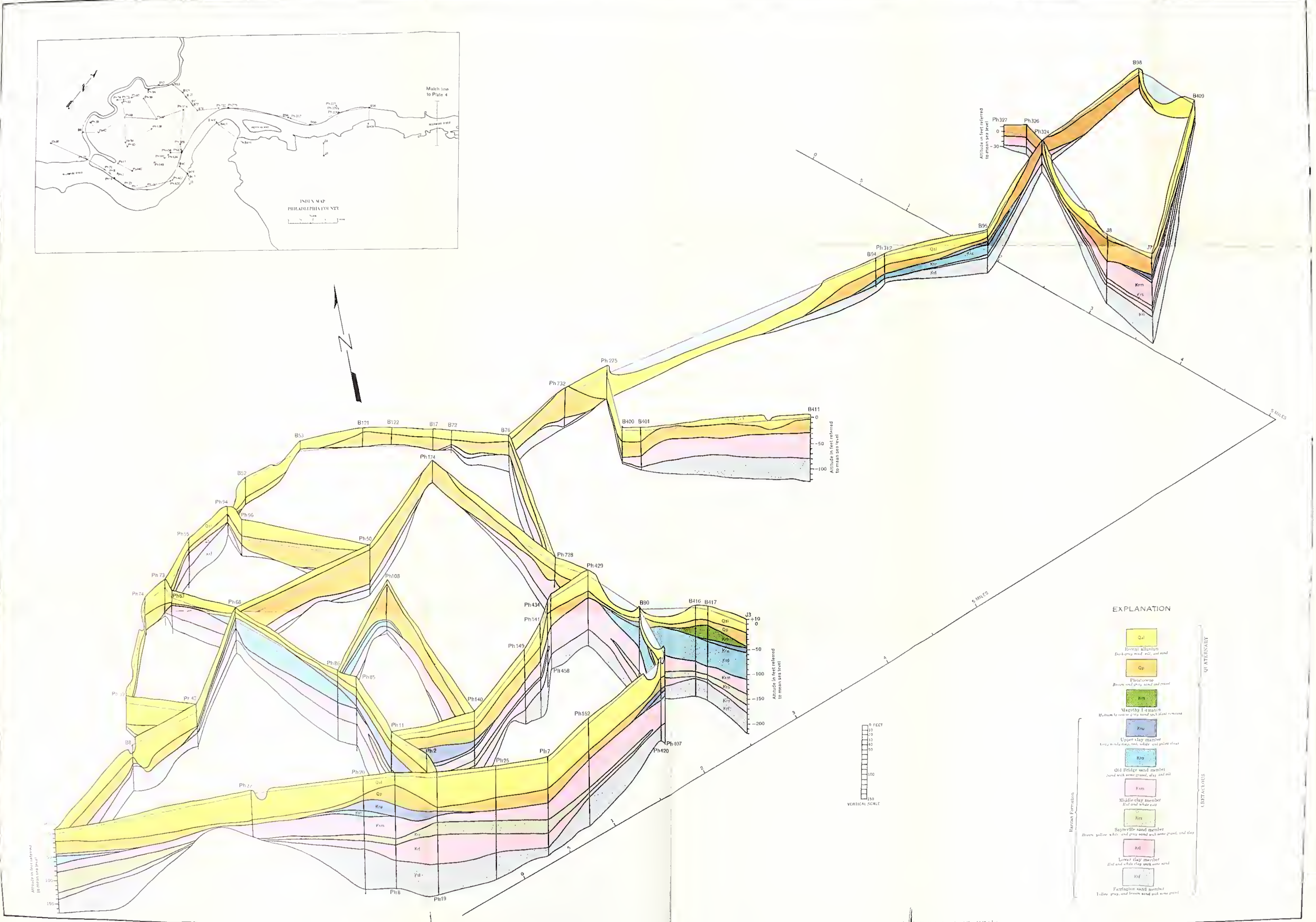


Plate 3 Fence diagram showing the subsurface stratigraphy of the Coastal Plain sediments in Philadelphia County, Pennsylvania.

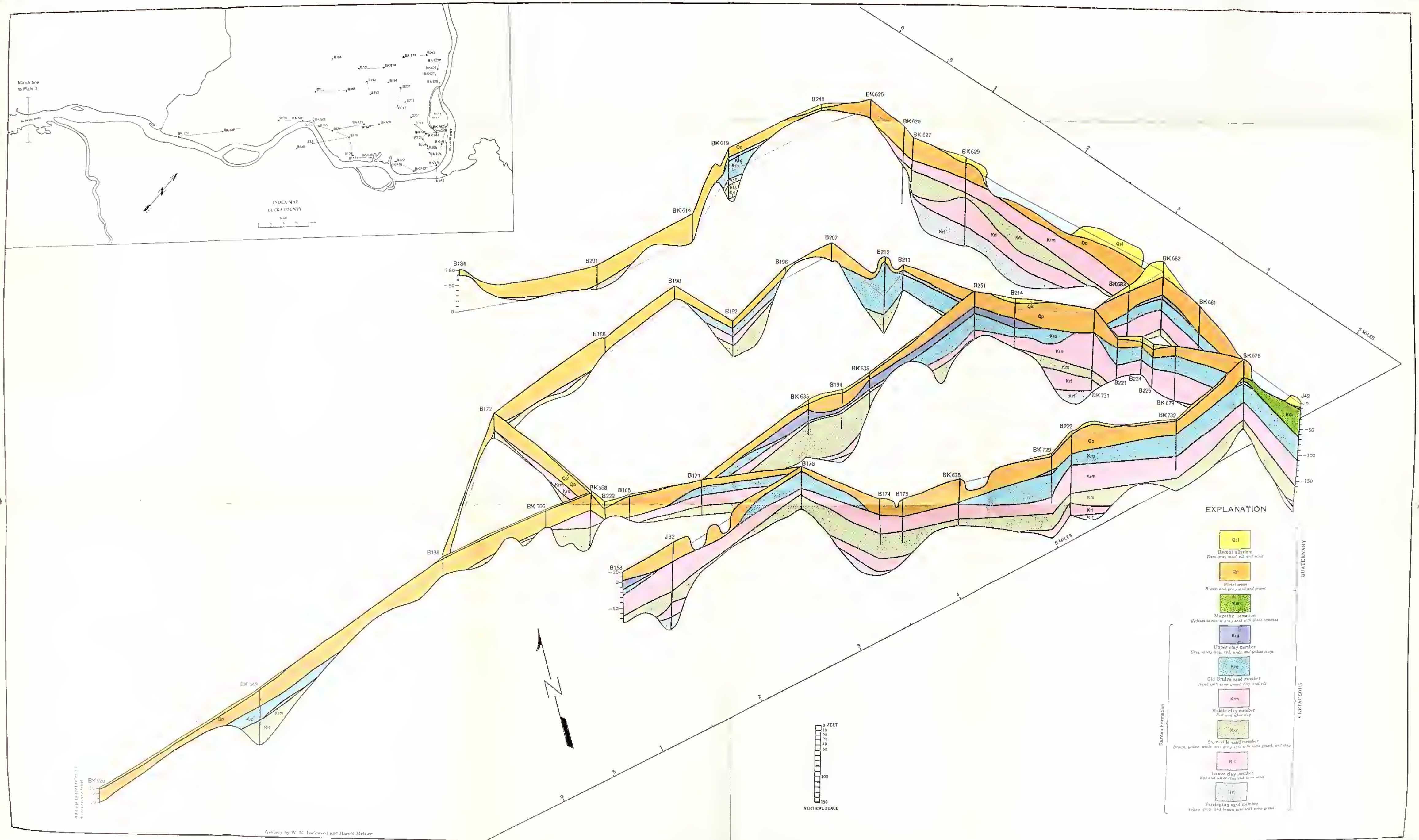


Plate 4 Fence diagram showing the subsurface stratigraphy of the Coastal Plain sediments in Bucks County, Pennsylvania.

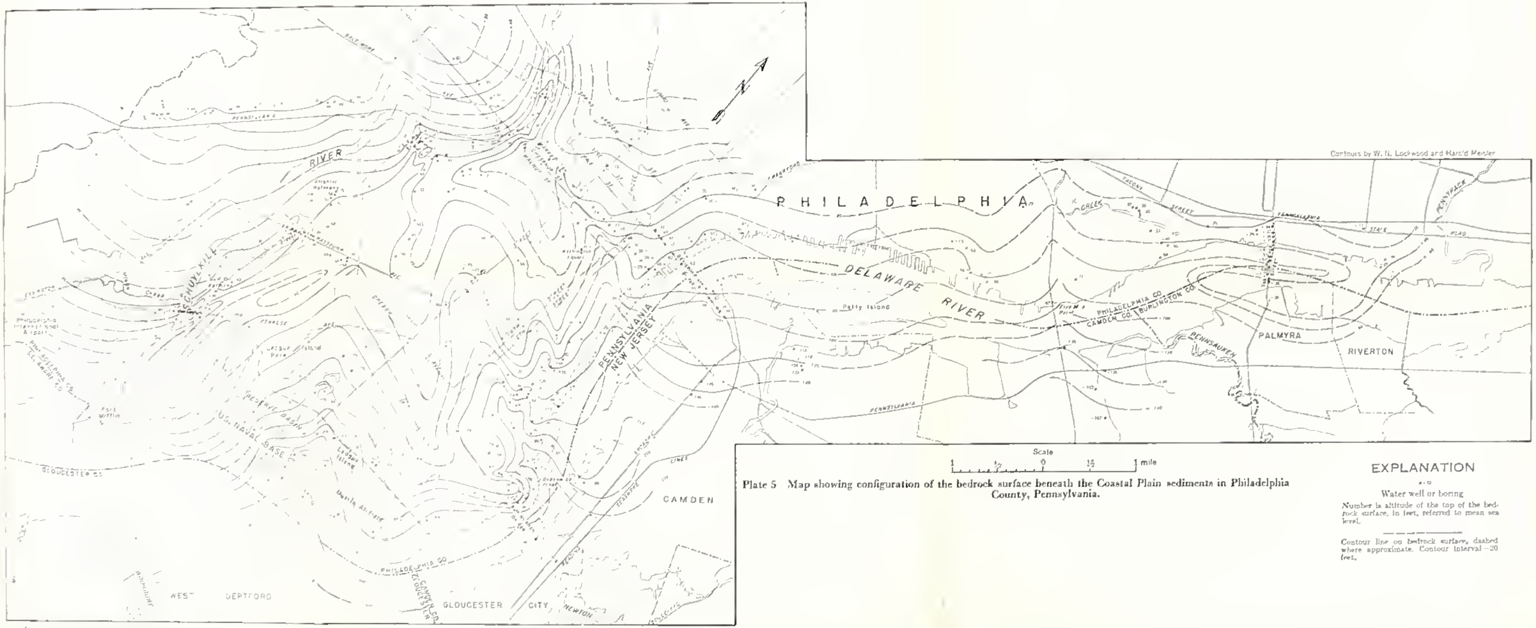


Plate 5 Map showing configuration of the bedrock surface beneath the Coastal Plain sediments in Philadelphia County, Pennsylvania.

EXPLANATION

Water well or boring

Number is altitude of the top of the bedrock surface, in feet, referred to mean sea level.

Contour line on bedrock surface, dashed where approximate. Contour interval—20 feet.

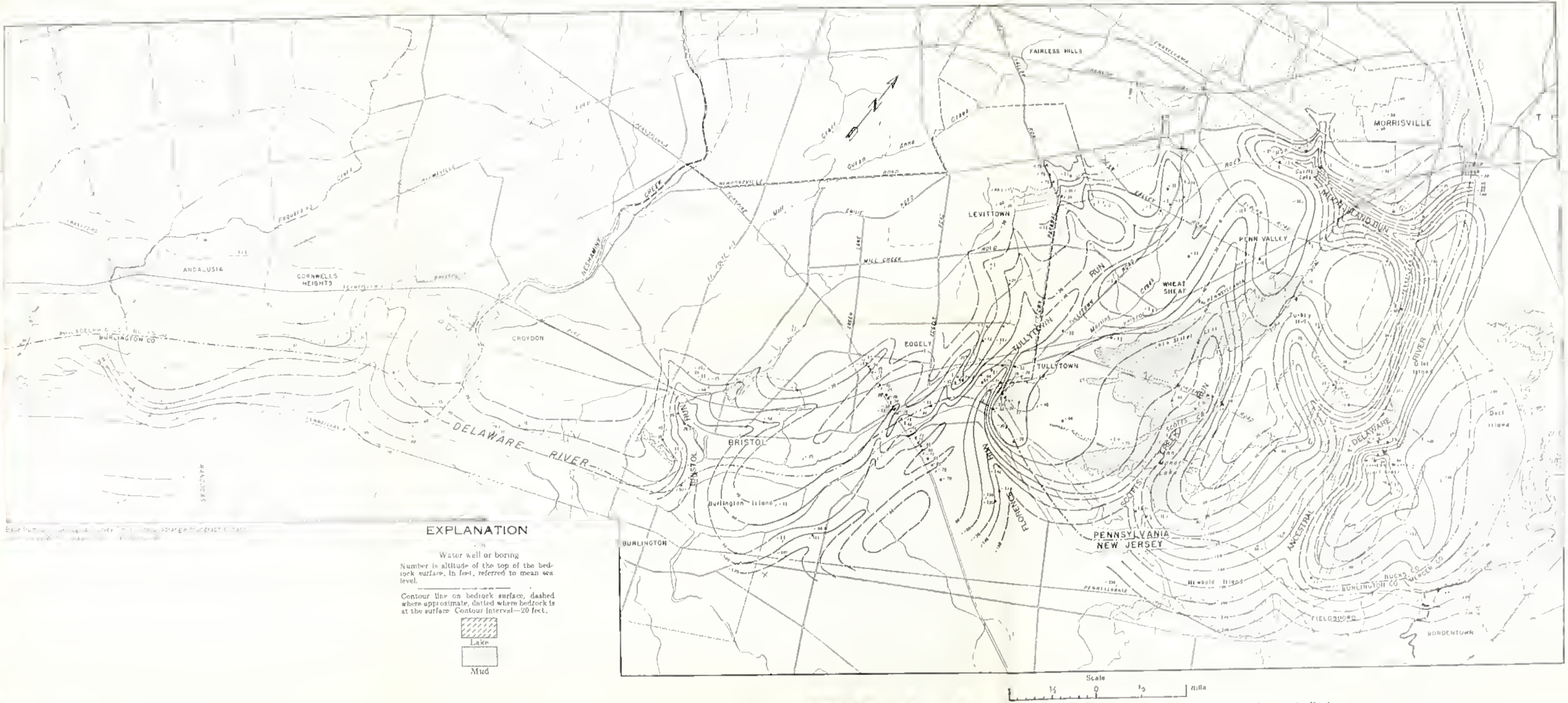


Plate 6. Map showing the configuration of the bedrock surface beneath the Coastal Plain sediments in Bucks County, Pennsylvania.

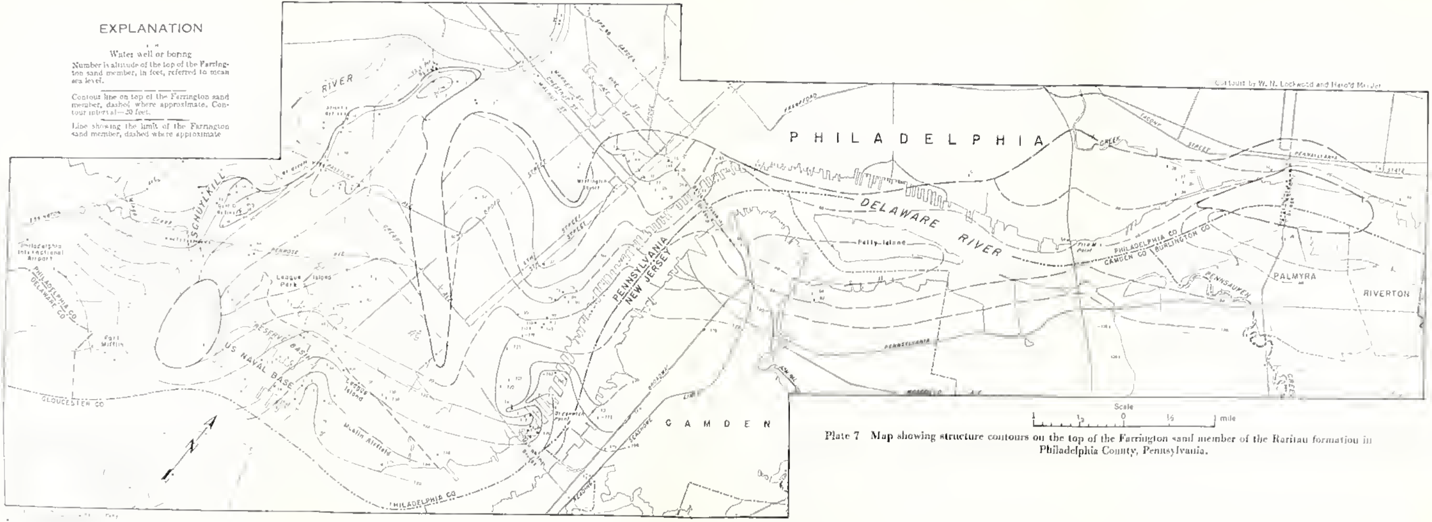


Plate 7 Map showing structure contours on the top of the Farrington sand member of the Raritan formation in Philadelphia County, Pennsylvania.

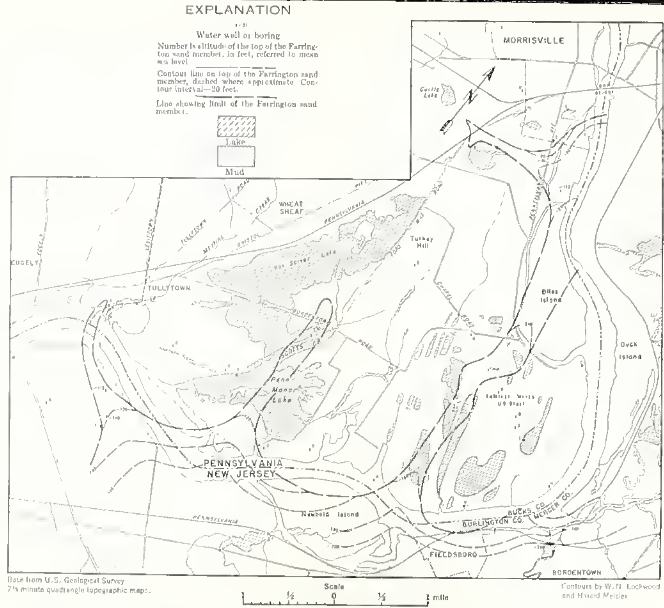


Plate 8 Map showing structure contours on the top of the Farrington sand member of the Raritan formation in Bucks County, Pennsylvania.

EXPLANATION

Water well or boring
Number is the thickness of the Farrington sand member in feet.

Isopachous line, dashed where approximate
Contour interval - 20 feet

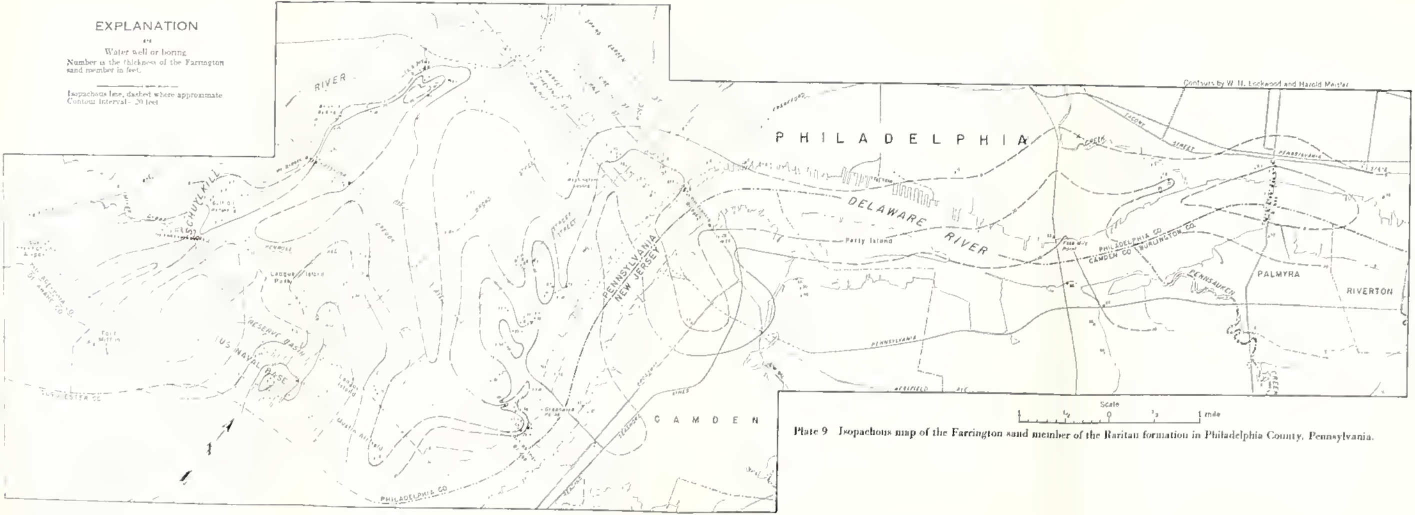
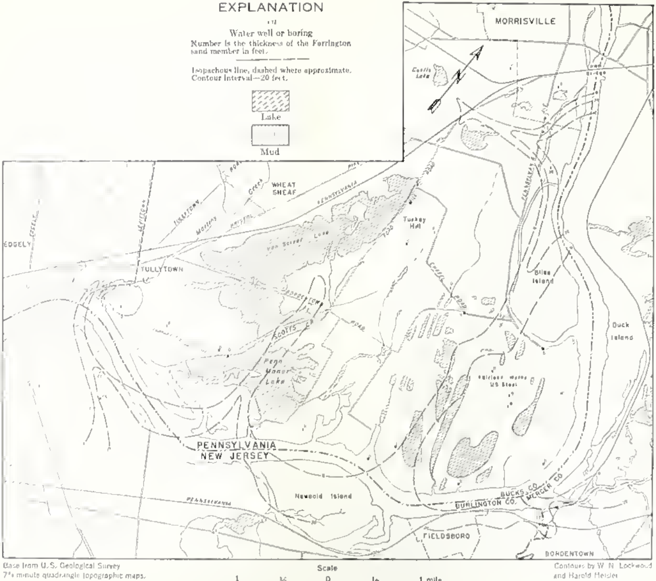


Plate 9 Isopachous map of the Farrington sand member of the Raritan formation in Philadelphia County, Pennsylvania.



Base from U. S. Geological Survey 7½ minute quadrangle topographic maps.

Contours by W. N. Lockwood and Harold Meisler

Plate 10 Isopachous map of the Farrington sand member of the Raritan formation in Bucks County, Pennsylvania.

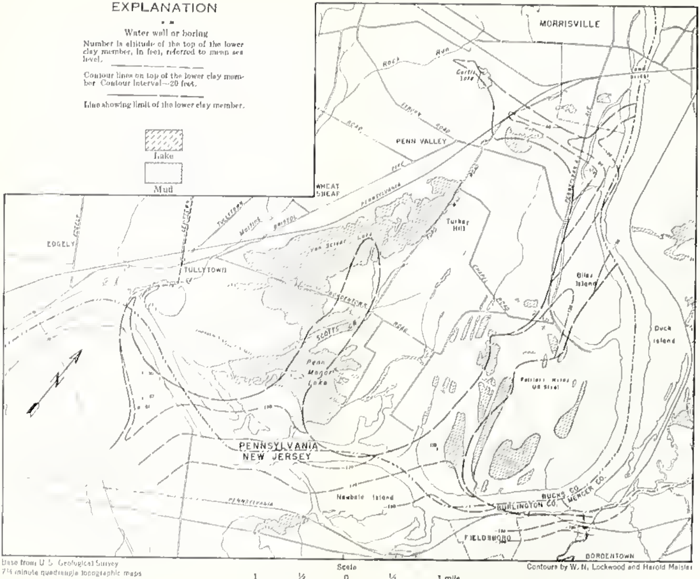
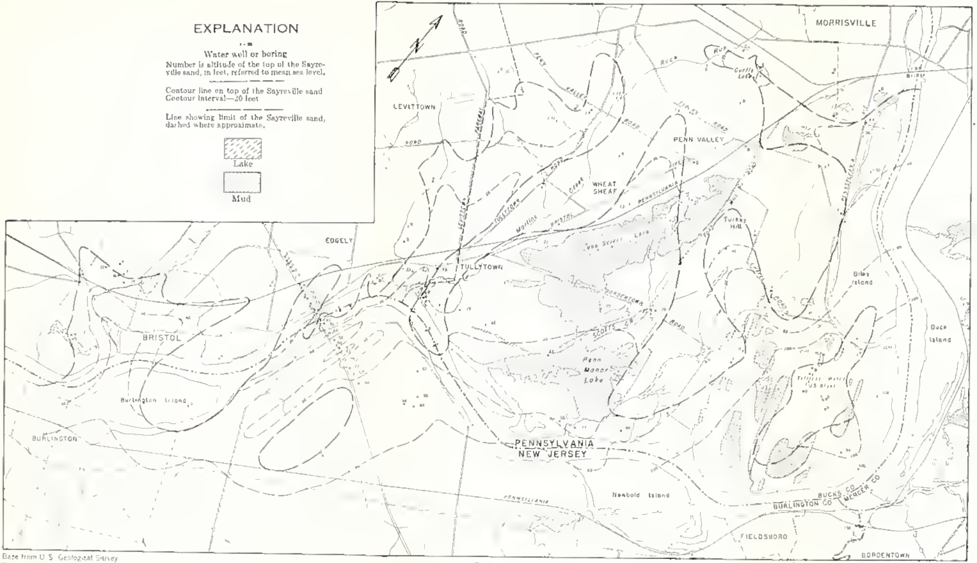


Plate 11 Map showing structure contours on the top of the lower clay member of the Raritan formation in Bucks County, Pennsylvania.

Plate 12 Isopachous map of the lower clay member of the Raritan formation in Bucks County, Pennsylvania.



Base from U.S. Geological Survey
7½ minute quadrangle topographic maps

Scale
1 ½ 0 ½ 1 mile

Contours by W. N. Lockwood and Harold Meisler

Plate 13 Map showing structure contours on the top of the Sayreville sand member of the Raritan formation in Bucks County, Pennsylvania.

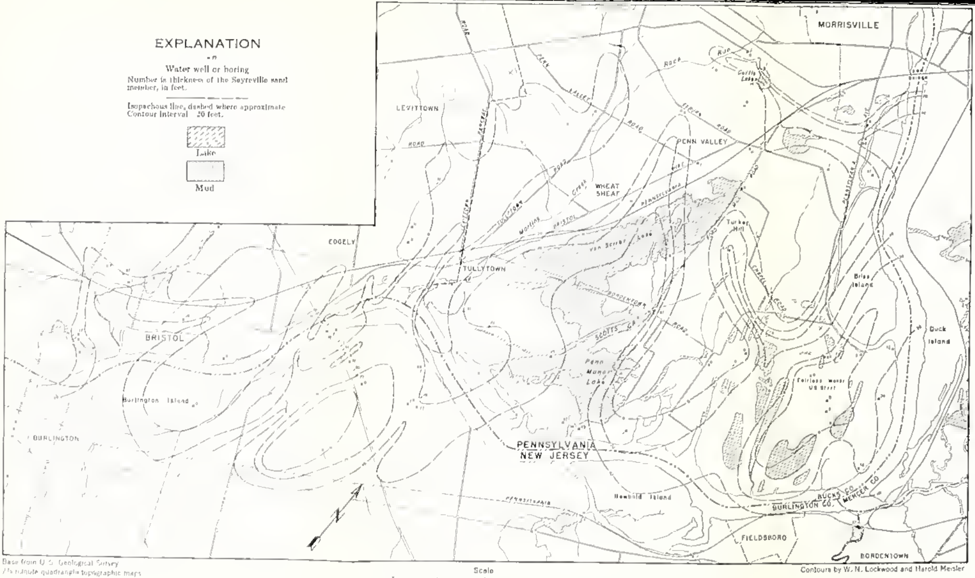


Plate 14 Isopachous map of the Sayreville sand member of the Raritan formation in Bucks County, Pennsylvania.

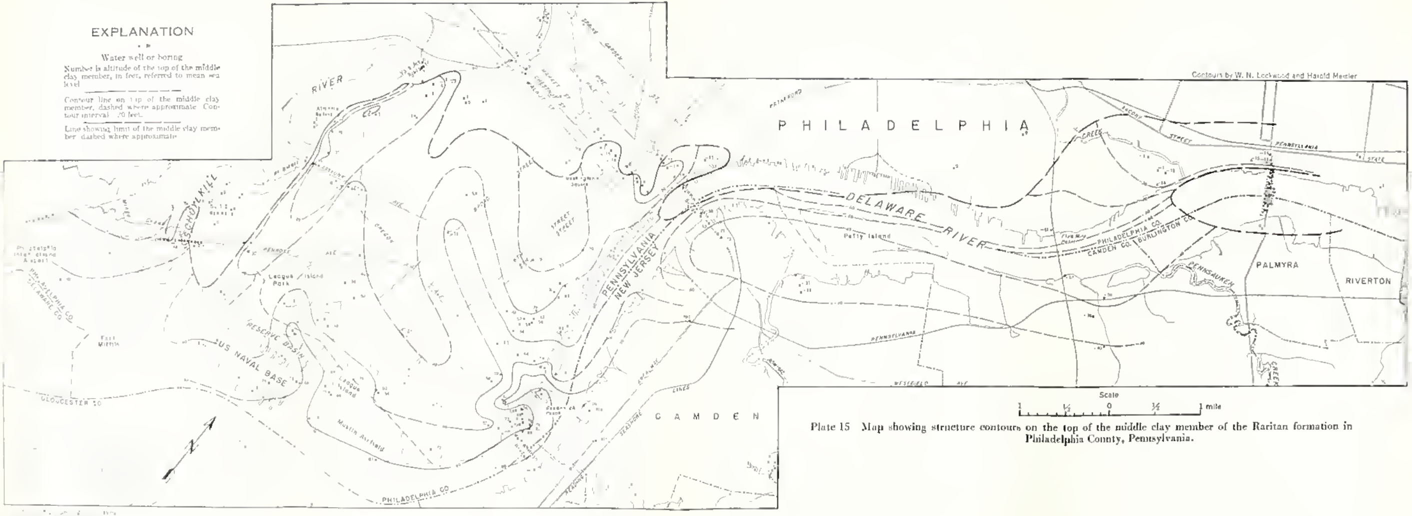


Plate 15 Map showing structure contours on the top of the middle clay member of the Raritan formation in Philadelphia County, Pennsylvania.

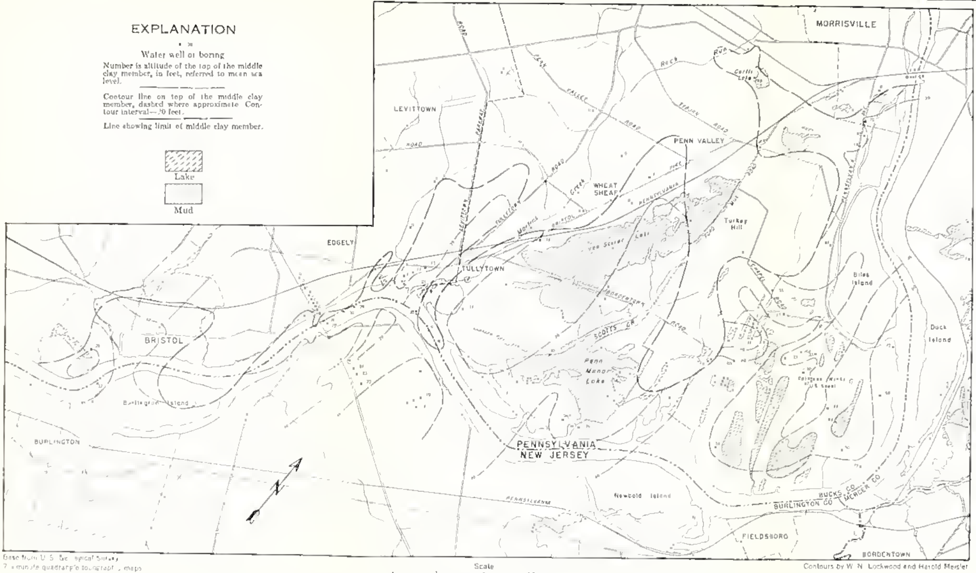


Plate 16 Map showing structure contours on the top of the middle clay member of the Raritan formation in Bucks County, Pennsylvania.

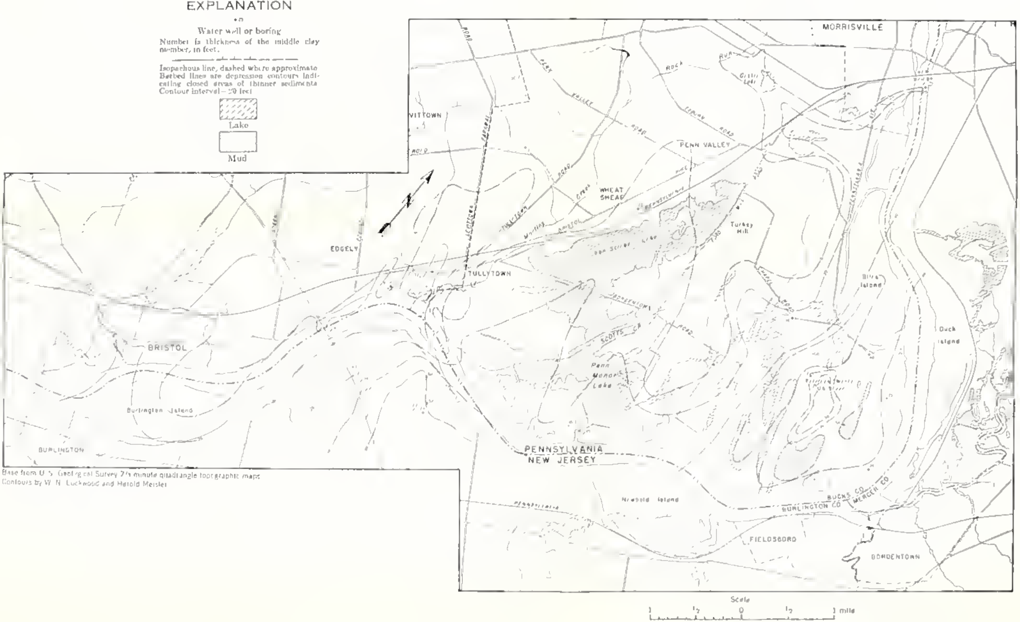


Plate 17 Isopachous map of the middle clay member of the Raritan formation in Bucks County, Pennsylvania.

EXPLANATION

Water well or boring
Number is thickness of the members, in feet

Isopachous line, dashed where approximate
Contour interval 20 feet

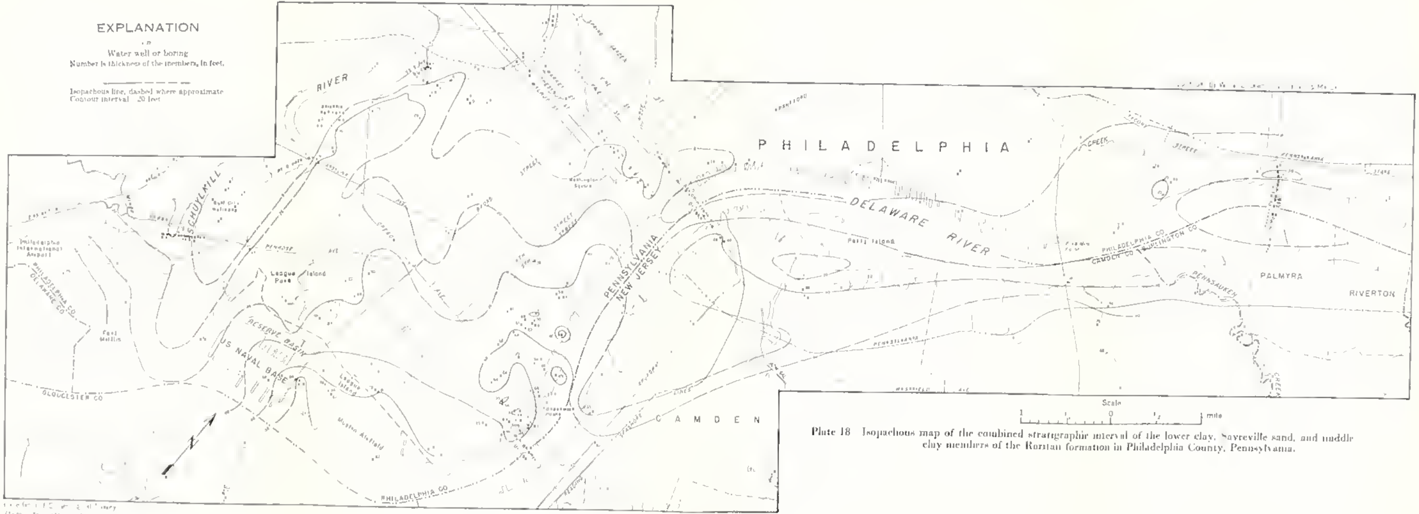


Plate 18 Isopachous map of the combined stratigraphic interval of the lower clay, Sayreville sand, and middle clay members of the Raritan formation in Philadelphia County, Pennsylvania.

Plate 19 Map showing the extent of the artesian system in the Coastal Plain of Southeastern Pennsylvania.

EXPLANATION

Extent of the artesian system, dotted where approximate

Area in Pennsylvania where the artesian system is present

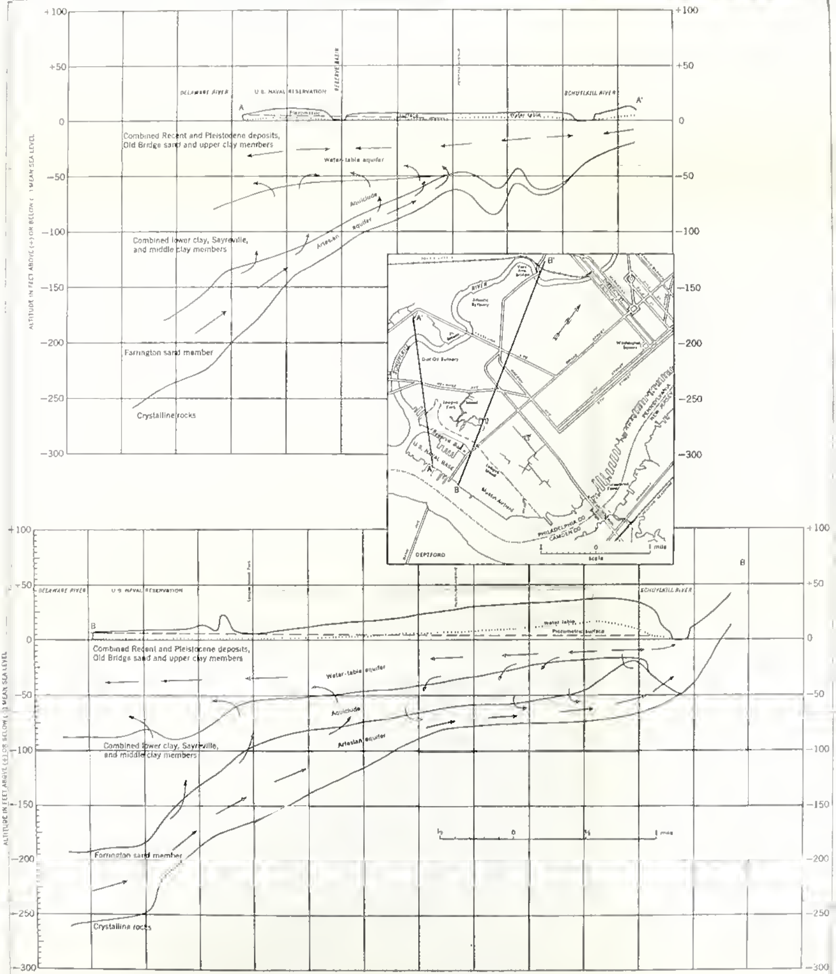


Plate 20 Cross sections showing probable directions of ground water movement in and between aquifers under natural conditions near the junction of the Delaware and Schuylkill Rivers in Pennsylvania.

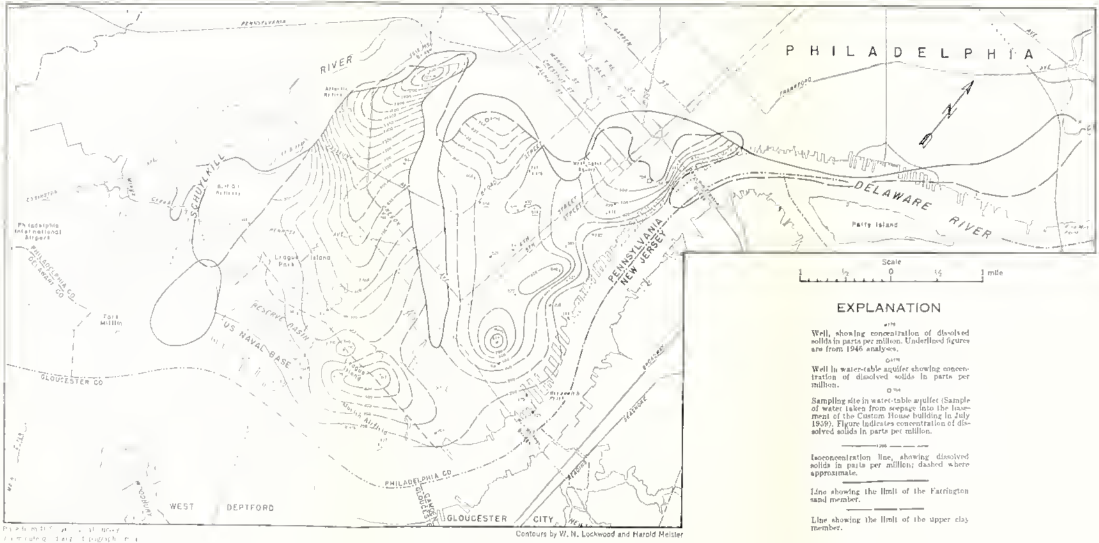


Plate 21 Map of the Philadelphia area showing the variation in the dissolved mineral content of water from the Farrington sand member of the Raritan formation, 1956.

Plate 22 Map of Philadelphia area showing the variation of the concentration of sulfate of water from the Farrington sand member of the Raritan Formation.